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Chicago Number

THE SURGICAL CLINICS of NORTH AMERICA

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WHEN ARE GYNECOLOGICAL OPERATIONS INDICATED?

N SPROAT HEANEY M.D., F.A.C.S.

The natural progress of a cancer leads to the death of the host. Twisting of the pedicle of an ovarian cyst produces great pain, gangrene of the tumor may result and though the patient may in some instances recover spontaneously after a long illness the necrotic tissue usually becomes infected and results in an abscess or a generalized peritonitis with liability of death. An ectopic pregnancy only rarely is carried to viability, more often it ruptures early and a life endangering hemorrhage results.

In such conditions where we can accurately prophesy the progressive dangers of conservative management the indications for operative treatment are clear and indisputable.

A vesicovaginal or rectovaginal fistula or a third degree tear of the perineum makes a woman so uncomfortable that although no danger to life exists yet an operation is indicated because the possibilities of satisfactory relief through spontaneous cure or through artefacts are remote.

When a condition exists that seriously jeopardizes life or causes prolonged discomfort or pain there can be no question as to the advisability of an operation if it offers a reasonable prospect of relief.

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SERIOUS DISEASE

There are many gynecological conditions, however, which do not immediately threaten life or produce invalidism, yet which in the opinion of many practitioners demand operation. It is the intent of this discussion to outline the indications and the contraindications to operation in some of these conditions. It is of course understood that the discussion cannot be encyclopedic.

BIRTH INJURIES

Birth injuries may cause various impairments of pelvic function. Relaxation of the urethra with subsequent incontinence upon coughing or sneezing, may result in a moderate cystocele or rectocele or partial descent of the uterus may occur. These may be particularly annoying immediately after delivery and be curable by operation. If time is allowed for the patient to fully convalesce, however, the symptoms may disappear and be greatly ameliorated. Complete relief of incontinence of urine may sometimes be obtained by fitting the patient with a pessary so that just enough pressure of the anterior bar against the urethra restores continence. Similarly a pessary may support the pelvic structures and completely dispel the bearing down sensations. In later years if the patient feels that she has borne her quota of children an operation may be advisable and the feasibility of a sterilizing procedure may also then be taken under advisement.

When one encounters the mother of four or five children who at the age of forty years appears to require a hysterectomy and a plastic procedure on the pelvic outlet after having had a prophylactic plastic operation after each child birth one cannot help but wonder if this patient has not been abused. What have her prophylactic operations prevented? And why is it necessary to operate immediately to prevent a condition which could be treated surgically and with no more danger in later years if it develops. If a tear of the cervix has reduced the retentive power of the uterus to the extent that practically painless abortions result the cervix needs to be repaired. Or if the cervical canal is so short and patent that vaginal flora can invade the uterus and produce menorrhagia an operation may be advisable. In most in-

stances of cervical laceration however destruction by cauterization of the exposed cervical mucosa back to the functional external os will rid the patient of all symptoms attributable to her injury. I have yet to see a cancer of the cervix which in my mind occurred as the result of a tear of the cervix nor have I ever seen one prevented by a prophylactic repair.

RETROVERSION OF THE UTERUS

Patients with retroversion of the uterus are frequently subjected to operation and quite frequently the operation does not relieve the patient of the symptoms for which she welcomed the procedure. Backaches are often blamed upon a retroversion but one must remember that extrapelvic causes for backache outnumber the pelvic causes. If the backache is elsewhere than sacral the origin probably is not pelvic. If it is sacral in location the examiner must eliminate other possible pathological entities as causes. Is the cervix perfectly clear of infection? Is an erosion—even a small one—present or is there marked endocervicitis with a quantity of glairy or purulent mucus? The cervical disease must be cured before the retroversion can be blamed for the backache. If this is done the backache in most cases disappears unless there are present still other complications such as inflammation of the appendages or endometriosis. If the cervix is quite badly inflamed and the retroversion is postpartum rather than congenital in origin the uterus may return to its normal position when the inflamed cervix is cured.

The relief of symptoms by the insertion of a pessary is not positive proof that the symptoms were produced by the retroversion. Complete relief may be obtained by a properly fitted pessary even when the cervix is extensively eroded and a marked endocervicitis is present. Support of the uterus in its proper position relieves the congestion producing the backache. Removal of the pessary and successful treatment of the cervical condition may cause the backache to disappear in these cases even though the uterus remains retroverted. When the cervix is finally normal you may be surprised to find, if you have not had the experience before,

that the accompanying menorrhagia and dysmenorrhea have also disappeared they also were due to the inflammation and consequent congestion. If a degree of menorrhagia is still encountered it may sometimes be controlled by styptics.

Failure to obtain relief for patients by retroversion operations is thus seen to be due not so much to the fact that the wrong type of round ligament operation was selected as to the presence of associated disease which was not taken care of at the time of the operation or quite as often to the fact that the symptoms ascribed to the displacement were due to other abnormalities.

ENDOMETRIOSIS

Endometriosis because of its invasive tendency is usually believed to call for immediate operation and unless all traces of the affection are surely eradicated by dissection the ovaries frequently are removed without respect to age. That this view is not a proper one is shown by a large experience with conservative surgery over a considerable period of time. As the course of endometriosis is usually progressive the disease may it is true cause extensive damage to the ovaries or invade the broad ligament and occlude the ureter or spread over the rectum. Instances are frequently seen however in which the disease does not progress beyond its initial stage. I have seen proved cases that have remained quiescent and symptomless for periods of twenty or more years. Operation is not indicated simply because typical puckered nodules are found in one or both sacro uterine ligaments but only in the event that the nodules menstruate and cause pain and the difficulty seems to be progressive. Progress in the disease may be due to the spread from the original graft or to successive inoculations of endometrium by back flow through the tubes.

If the uterus is retroverted and the endometrial implants are producing symptoms the implants should be eradicated and the uterus put in position for with the uterus retroverted there is a strong probability that regurgitation of endometrial grafts back through the tubes will continue. When fibroids are present they too by distortion of the uterine cavity may cause the menstrual blood to flow back through the tubes.

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Endometriosis secondary to fibroids of the uterus demands surgical intervention as will be discussed later. The uterus may be already past saving but timely operation may conserve the ovaries.

At operation for endometriosis the endometrial grafts should be removed as thoroughly as possible by sharp dissection. Small areas not easily removed by the knife may be destroyed by the light nasal cautery, and larger areas in the rectum or posterior wall of the uterus not removable by dissection may be destroyed by a larger cautery cautiously used with the flat surface ironing out the grafts. One should not go to dangerous extremes to remove all traces of the disease. If it should happen that a small area escapes attention and later grows and causes symptoms, the nature of the disturbance will be immediately recognized and the recurrent growth can be destroyed by x-rays if castration is not a bar. No operation for endometriosis is complete unless the cervix is thoroughly dilated so as to guard against the recurrence of backflow of menstrual discharges. So also, if an early case of endometriosis is encountered in which symptoms are not severe enough to warrant a major operation a dilatation of the cervix at least should be done so that subsequent grafts may not be added to those already present.

FIBROIDS OF THE UTERUS

Fibroids of the uterus frequently do not interfere with pregnancy or the menstrual function in the slightest and may exist many years without much increase in size. Since malignant degeneration of fibroids is rare—if it ever does occur—such tumors of course do not require removal simply because they are present. If a fibroid is so located or so large that pressure results it had best be removed. When a fibroid approaches the size of a fetal head even in the absence of symptoms an operation should be taken under advisement especially if the uterus is not particularly nodular. The absence of many nodulations suggests that the tumor may be a single one. Every fibroid has but one nutrient vessel and when the tumor has grown beyond the potential capacity of its vessel to nourish it the tumor may undergo necrosis and

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ovaries or in the rectum. If the uterus is without value to such a patient a hysterectomy should be done before the ovaries also are jeopardized. Again in the event that fibroids begin to grow rapidly or become tender to touch or painful they had best be removed for such symptoms are indices of degenerative change.

OVARIAN TUMORS

Ovarian tumors are a source of real danger because of their propensity for twisting upon their pedicles, their low resistance against infection and their high potentiality of malignancy. When they are found before puberty and after the climacteric they should be removed by operation without undue delay, for a high percentage of such tumors at these ages are malignant.

During menstrual life the chance that an ovarian tumor may be a *corpus luteum cyst* should constantly be borne in mind. Corpus luteum cysts are especially apt to be found in early pregnancy, when they may be mistaken for an ectopic pregnancy. They are transitory and usually disappear within three weeks by the time the next ovulation is due. The presence of a corpus luteum cyst should be suspected if the tumor is the size of a medium or small orange, globular and freely movable. If these are the findings, a waiting period of three weeks may save the surgeon the embarrassment of operating upon a disappearing cyst and the patient an unnecessary operation.

If an ovarian cyst appears a few weeks or a month or so after an operation for inflammatory disease in the pelvis, when the tubes have been removed or an ovary has been resected the cyst is probably *inflammatory* in nature or due to disturbed blood supply. Such a cyst is usually fixed, cannot twist on its pedicle, carries no risk of becoming malignant and is only important because it produces pain. If the cystic ovary is the only ovary in a young woman, it is better than no ovary at all provided the pain can be eliminated. If the cyst is found by rectovaginal examination to be close against the vaginal vault it can sometimes be drained vaginally by trocar or aspirating needle with the guidance of rectoscopy.

inal palpation and under surgical precautions. If it cannot be safely approached in this manner it may be drained through a colpotomy incision under the guidance of direct vision. In certain instances in my experience incision and drainage have been repeated two or three times before the swelling finally disappeared or was so flaccid and small that no pain was produced. In a young woman this is a valuable technic. In a woman near the menopause the ovary, if painful, may not be considered so valuable and its removal may be considered.

Ovarian tumors that are *persistent* or swellings of the ovary that are *irregular* or *fixed* should be operated upon early, for these findings are some of the characteristics of malignant growths. Tumors that increase rapidly in size or are associated with ascites may be malignant though frequently they are papillary or pseudomucinous cystadenomas. Fibromas of the ovary are also frequently accompanied by ascites. Abdominal exploration should be employed even though removal of the tumor at first seems impossible. An operation with a certainty of cure may occasionally be done in a case that at first seemed hopeless.

PELVIC INFECTIONS

Postabortive, puerperal and gonorrheal pelvic infections in general to be treated medically. When the temperature curve and pelvic findings show a localized pelvic abscess which is slow in resolving, convalescence is greatly hastened by a colpotomy incision and drainage. Cases thus managed heal more quickly and with fewer residual swellings and permanently closed tubes than others. When the patient is making a rapid convalescence, however, incision and drainage are unnecessary.

Now that we have the sulfa drugs the need for pelvic drainage of pelvic abscesses has been very much reduced. Patients with rapidly fulminating postabortive and puerperal peritonitis are now again to be subjected to operation. Incision in the midline, draining of localized abscesses, the insufflation of sulfanilamide into the pelvic cavity, closure of the abdominal incision and the oral or intravenous adminis-

tration of sulfur drugs comprise a technic that is saving many of these patients, whose cases previously were considered hopeless

CERVICAL ATRESIA AND STRICTURE

Increasing recognition is being given to the importance of obstruction of the cervix as a cause of menstrual complaints. Obstruction may result when the normal cervical opening is too small or when the cervical canal is strictured. Atresia of the cervix is a frequent cause of cramps at the onset of the period, it tends to progress with time and may lead to a back flow of menstrual blood and the production of endometriosis. In the absence of erosion or endocervicitis, dilatation of the cervix so successfully relieves menstrual cramps that it should more universally be employed. Young girls who are thus treated early for dysmenorrhea may be saved much future pelvic complaint. In older women strictures too frequently result from intracervical cauterizations. They follow conization and Sturmdorf operations so commonly as to discredit these procedures. The administration of radium to the cervix and amputations of the cervix and trachelorhaphies furnish their percentages of strictures.

During menstrual life these strictures obstruct the outflow of menstrual blood so that backache may occur together with a prolonged menstrual flow, the discharge being of a malodorous character. Suggestive spotting may take place for several days before and after the menstrual period and putrid blood may appear several days after the period is over. As the difficulty increases a pyometra forms. It is important that the cervix be patulous even after the menopause; otherwise pus or blood may accumulate in the uterus. A malignant tumor of the corpus may thus go undetected until the accumulated blood which otherwise would have escaped to give early notice of danger produces so much pain that the patient seeks relief only to find that the cancer has passed the bounds of curability. Testing the patency of the cervical canal is a part of every thorough pelvic examination.

HYPERTENSIVE TOXEMIA OF PREGNANCY*

WILLIAM J. DIECKMANN, M.D.†

APPROXIMATELY 5 per cent of pregnant women who are delivered in hospitals in the United States have one or more of the following signs: edema (excessive weight gain), hypertension or albuminuria. The maternal mortality for these patients with nonconvulsive toxemia ranges from zero to 10 per cent, averaging 1.7 per cent. Twenty-four per cent of the patients who have one or more of the above signs have cerebral, visual, gastro-intestinal or renal symptoms which should be regarded as premonitory to the onset of convulsions or coma. Five per cent of the toxemic patients have eclampsia with a maternal mortality which ranges from 2 to 30 per cent, averaging 13 per cent. Obviously eclampsia should be prevented.

Approximately one-half the patients who have so-called toxemia of pregnancy have permanent vascular disease as the basis for the condition. The hypertension may be present before or may develop during pregnancy. The following history is of a typical case of severe hypertensive disease with early renal involvement.

ANALYSIS OF A CASE

E. A. was twenty-nine years old when first seen by us in 1939. The previous obstetric history is given in Table 1. In 1940 the patient had an abruptio placentae at twenty-eight weeks with a stillborn previable fetus which weighed 810 gm. The normal blood pressure on admission was due to shock caused by the hemorrhage. The patient's blood pressure remained elevated after this delivery but she was very anxious.

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to have a child Her last menstrual period was January 2 1941 She was first seen on March 12 1941 and admitted to the hospital for study and treatment The cold pressor test gave an increase in the systolic blood pressure of 45 mm (30 mm or more is abnormal) The pituitrin test gave an increase of 15 mm in the systolic blood pressure (25 mm or more is abnormal) Essential data are given in Table 1

TABLE 1
ESSENTIAL DATA IN CASE OF HYPERTENSIVE TOXEMIA OF PREGNANCY

D	Weight Kg	Edema	Blood Pressure mm Hg	Prot	Remarks—Treatment
1933					23 yrs 11 Spontaneous ab
1935					3 m
1936			170/		Spontaneous ab 26 m
1938			135/100		Blood 7 m became f
6/16/39			150/105	0	10 m
					Spontaneous ab 16 m
12/13/39	66.5	0	140/95	0	At term 6 22/40 Hb 114 gm. S
					pro 78 gm. Ure 1 67
					1 blood 28 BUN -12
3/5/40	72.0	0	145/100	0.3	
3/29/40		0	110/70	++ cas	Abrupt placental blood transfusion
					800 cc
3/30/40			160/110	0.6	
4/12/40			125/75	+	Ure clearance 90 Blood re 6 Hb
5/7/40	65.5	0	170/115	0	13 m S prot 8 gm BUN -9
7/16/40	64.0	0	150/100	0	
3/12/41	68.6	0	155/115	0	At term 10/9/41 Admitted to hospital
					U 1 63 Blood re
					40 Hb 117 gm. S prot 6.8 gm
3/16/41			140/90	0.3	BUN -10 I renal insufficiency
3/20/41	70.0	0	130/90	0.2	Thyroid 0.12 gm d l
7/8/41	74.7	0	160/115	+	Alph oc phol BUN -8
7/29/41	76.5	+	175/120	+	Blood est S d m po d l
8/12/41	75.0	0	220/130	+	Adm d l hospital S d t
					BUN -9
8/18/41	74.0	0	195/125	+++	Urea 1 47 Blood re 31 Hb
				ca	117 gm S p 67 m.
8/21/41			170/115	+++	Lap b l my t 33 t
				ca	
9/4/41	69.1		185/110	++	U 1 62 Blood re 3 Hb
11/26/41	65.0		18/120	++	128 gm Se p t 75 gm.
				asls	U 1 62 Blood 3 Hb
4/22/42	68.0		210/140	+	130 m S pro 76 gm H ad hes
					d us Rest d ph b b tal
					0.03 gm.

Patients with severe vascular renal disease usually have babies that are small for the period of gestation and while the menstrual age of the fetus is of more importance than the weight yet a baby born at thirty two or more weeks gestation whose weight is below the normal will have less chance of survival than others This patient therefore was given

500 cc of 20 per cent glucose three times daily for a week in an endeavor to increase the size of the fetus and placenta. The time for each injection was at least one hour. She was also encouraged throughout pregnancy to eat hard candy continuously in an endeavor to maintain a high level of blood sugar. This therapy has resulted in the birth of fetuses that were larger than previous babies born to the same woman at corresponding periods of gestation. The patient was also given 2 grains of thyroid daily because her basal metabolic rate was minus 12. Metabolic tests taken at two month intervals were always negative. The usual finding in these patients is that, despite the stimulus of pregnancy and thyroid medication, the basal metabolic rate does not increase. The patients also are either overweight or tend to gain weight easily.

The caloric intake of the patient was kept at 2000 calories by limiting primarily the fat intake. The patient ate from 80 to 120 gm of protein daily. Our normal patients may have milk throughout pregnancy but we insist on a quart a day after the twenty eighth week. These patients with vascular renal disease are encouraged to drink a quart of skimmed milk or buttermilk throughout pregnancy. Since abruptio placentae is supposedly amenable to treatment with vitamin E and since fetal death is due to marked placental infarction, retroplacental hematoma or abruptio placentae all having the same etiology and differing only in degree, we have been giving these patients vitamin E beginning at the twenty fourth week of pregnancy. This patient was given 160 mg of alpha tocopherol daily. Neither substance was of value. On July 29 the patient was placed on a sodium and chloride poor diet because of beginning edema.

Throughout her pregnancy the patient had been told to spend ten hours in bed each night and to rest an hour in the morning and afternoon. At twenty eight weeks she was told to spend all her time in bed and at thirty weeks she was brought into the hospital with the idea of terminating the pregnancy at thirty two weeks. Ophthalmoscopic examination in 1940 had shown no retinal changes but in 1941 there was generalized constriction of the retinal arteries and edema.

An elective cesarean section was performed on August 21.

when the patient was thirty three weeks pregnant. The fetus was 41 cm long and weighed 1645 gm. These are normal figures. A tubal ligation was carried out. The pregnancy would not have been interrupted had the albumin in the urine remained minimal but as is evident from Table 2 it showed a constant increase and our experience has been that if the twenty four hour albumin amounts to 5 gm or more for a period of a week or longer the fetal mortality becomes very high. In view of the steady increase in albumin despite bed rest, diet and mild sedation it was therefore deemed advisable to terminate the pregnancy. The postpartum course was uneventful and when the patient was seen subsequently the

TABLE 2
TWENTY FOUR HOUR URINE

Date	Volume C	Non-protein Nitrogen Gm.	Protein		Sodium Chloride Gm.
			Qualitative	Gram	
3/17/41	2700	17.2	0	0.3	14.7
3/19/41	1300	16.1	+	0.2	12.3
4/22/41	3100	16.5	0	0.3	12.6
5/20/41	2900	18.3	0	0.2	13.1
6/24/41	3900	16.9	0	0.4	12.9
7/21/41	5900	15.0	0	0.4	12.6
7/9/41	2400	13.7	0	0.2	12.3
8/3/41	2900	12.1	+	1.8	3.2
8/12/41	2400	11.4	++	2.9	3.3
8/14/41	3400	12.7	+	2.4	3.1
8/16/41	2100	12.9	+++	4.2	2.7
8/18/41	4600	12.2	+	5.7	2.3
8/20/41	2100	13.7	++++	9.3	1.9
9/4/41	3200	14	+	1.1	7.9

blood pressure was still markedly elevated and will remain at this level.

The nonprotein nitrogen of the urine indicated that 80 to 115 gm of protein was being metabolized daily. This was the approximate intake of the patient.

The value of the twenty four hour determination of the albumin in the urine is illustrated by the data in Table 2. Qualitatively the urine was protein free in the first part of the pregnancy but it was not free when tested quantitatively. Furthermore the albumin on August 16 was 4.2 gm (qualitative 3 plus) while on August 18 it was 5.7 (qualitative 1 plus). The difference in the qualitative reaction is due to the varying volumes of urine.

A twenty four hour analysis of the urinary chlorides enables the doctor to determine how well the patient is limiting the salt intake. The chloride and sodium intakes will usually be less than 15 and 0.8 gm respectively if the urinary chloride is less than 1.8 gm or less than 3 gm as sodium chloride per twenty four hours.

DIAGNOSIS

Hypertensive patients show varying degrees of albuminuria, an abnormal Addis count and a renal function which is subnormal or at the lower limits of normal. As a rule the patients have no symptoms or signs and it is difficult for them to believe that they have a serious vascular renal disease. Pregnancy usually results in a further increase in the blood pressure which is always higher after each pregnancy. The history of repeated abortions, stillbirths or abruptio placentae is characteristic of severe hypertensive disease usually with renal involvement. Syphilis should always be excluded by a serologic test. This is especially important if the blood pressure and urine are still normal either early in pregnancy or between pregnancies. We have had a number of such patients each of whom has had from two to five pregnancies before she had a living child.

Renal function tests are of little value in the pre eclamptic patients but are of prognostic value in the other types of toxemia. Ophthalmoscopic examination is of value if pathologic changes are found, but normal findings may be present in grave toxemia.

Usually after several observations one is able to diagnose the toxemia as one of pre eclampsia or hypertensive disease.

TREATMENT OF HYPERTENSIVE TOXEMIA

The treatment of toxemic patients is summarized as follows:

Examination

Ambulatory Weekly or semiweekly

Hospital The patient is weighed and a twenty four hour urine examination for volume, quantitative protein and chloride and three determinations of the blood pressure are made daily.

Hypertension

Relaxation Ten hours rest at night and one hour twice daily. As term is approached more time may be spent in bed until all time is spent in bed.

Sedation Phenobarbital (0.03 to 0.06 gm or $\frac{1}{4}$ to 1 grain three times daily) luminal sodium (0.3 gm or 5 grains one or two times daily) subcutaneously in severe cases.

Elimination Soapsuds enema and mild laxative as needed.

Excessive Gain in Weight—The diet is composed of vegetables, fruits, lean meats which must be broiled, boiled or roasted, eggs and 500 cc skimmed milk or buttermilk. No pie, cake, bread, butter, cream, gravy, soup or table salt is used.

Pre eclamptic Salt poor diet, protein 60 gm, fat 75 gm, carbohydrate 230 gm, 1900 calories.

Eclamptic Fruits and fruit juices with sugar. Limited to five to ten days. One thousand calories.

Edema—A diet low in sodium and chloride. No salt or baking powder may be used in the preparation of foods or the baking of bread and rolls. Salt free butter is used. No crackers, pretzels, cheese, sausages, salted meats and fish, prepared salad dressings, canned soups, beer or patent medicines for the relief of gastric distress are permitted. There is a very low sodium content in flour, cream, macaroni, sugar, potatoes, squash, parsnips, lettuce, kidney beans, tomatoes and most vegetables and cereals. Eggs, meat, milk, beets, Brussels sprouts, corn, mushrooms, peas and spinach are reasonably low in sodium content and may be consumed in moderate amounts. Boiling the meat will remove most of the sodium. The broth must be discarded.

Watch water balance (weight). Ammonium chloride in 1 gm gelatin capsules are given eight times daily for five days and repeated after a five day interval. If symptoms of cardiac decompensation are present, the fluid intake is limited to 500 to 1000 cc.

Oliguria or Anuria—Intravenous injection of 500 to 1000 cc

of a 20 per cent solution of glucose two or three times daily. Occasionally 500 to 800 cc of a 30 per cent solution are necessary to produce a diuresis. If there is cardiac decompensation, 100 to 200 cc of a 50 per cent solution is used.

Proteinuria—Determination of the twenty four hour amount of urinary protein as a prognostic guide. No specific treatment.

Cerebral, Visual and Gastro intestinal Symptoms

Sedation. Intravenous glucose. Delivery.

The treatment of the case depends in part on the diagnosis. If the diagnosis is pre eclampsia, there is a possibility of eclampsia developing. If it is hypertensive or renal disease eclampsia is not likely to occur. There is a possibility of fetal death, especially after a gestation period of thirty weeks because of placental infarction, retroplacental hematoma or abruptio placentae.

Since pre eclampsia is caused by the pregnancy and since hypertensive and renal disease are usually made worse by pregnancy it seems obvious that termination of the pregnancy may be indicated. If severe toxemia is present the patient must be carefully observed and if labor does not ensue termination of the pregnancy is usually necessary.

The following criteria are indicative of severe toxemia.

"A" Group

The systolic blood pressure is constantly 170 mm Hg or shows a persistent daily increase.

The protein of the urine exceeds 5 gm in twenty four hours or the qualitative test of the twenty four hour urine is 3 plus.

The weight gain exceeds 100 gm per day.

Marked edema suddenly occurs.

'B' Group

Cerebral, visual or gastro intestinal symptoms arise.

Oliguria, anuria or hematuria occurs.

Jaundice develops.

The blood nonprotein nitrogen is 50 mg or more per 100 cc

The pulse rate is 120 or more

Edema of the lungs or cyanosis is present

The blood shows an increasing concentration as indicated by an abnormally high or increasing hemoglobin cell volume serum protein concentration or specific gravity

The advisability of terminating the pregnancy is dependent on the duration of the gestation the severity of the symptoms and signs and the condition of the cervix

Gestation of twenty six weeks or less should be terminated if more than one of the above listed criteria are present or if there is no appreciable improvement after seven days of adequate treatment

Gestation of twenty seven to thirty one weeks should be treated medically until thirty two weeks unless some B signs develop or the A signs persist or increase in degree despite treatment

Gestation of thirty two to forty weeks if B signs are absent should be treated medically until the cervix is ripe when induction of labor will be successful. If the A signs increase in degree or if any of the B signs appear the pregnancy should be terminated either by (1) rupture of the membranes and or insertion of a bag or (2) cesarean section if the cervix is uneffaced

Our results indicate that the careful medical management of the toxemic patient if begun early enough will usually prevent further increase in the severity of the symptoms and signs until the cervix is ripe. This means that the cervix is effaced and dilatable in the primipara or soft and partly dilated in the multipara as determined by vaginal examination and that labor can usually be successfully induced by rupture of the membranes. If contractions have not begun in twelve hours $\frac{1}{2}$ to 1 minim (0.03 to 0.06 cc) doses of pitocin should be given every thirty minutes until the contractions are occurring regularly at three to five minute intervals. Pitocin is suggested because the pre eclamptic patient usually has an oliguria which minute doses of pituitrin exaggerate

but it is not completely free of the antidiuretic hormone and should be used with caution

The patient who does not respond to treatment or has been neglected is treated by rupture of the membranes and/or the insertion of a bag if the cervical canal is less than 2 cm long or if there is no effacement, by cesarean section under *local anesthesia*

There is fairly general agreement that the pre eclamptic patient with severe symptoms should be treated as if she had eclampsia with great emphasis on immediate delivery because the average maternal mortality for eclampsia is 13 per cent and for nonconvulsive toxemia 17 per cent

TREATMENT OF ECLAMPSIA

General—Constant observation Retention catheter The temperature pulse and respiratory rate, blood pressure and urine volume should be determined every hour until the patient is conscious Oxygen is administered for marked cyanosis

Convulsions—One or preferably more of the following drugs are used

- 1 Magnesium sulfate 50 per cent solution 10 cc intramuscularly and 2 cc after every convulsion until controlled Maximal amount is 20 cc in twenty four hours
- 2 Luminal sodium subcutaneously 0.3 gm (5 grains) and if necessary repeated in twelve hours
- 3 Morphine sulfate 0.016 gm ($\frac{1}{4}$ grain) every hour until convulsions cease or respirations become twelve per minute
- 4 Chloral hydrate 2 gm (30 grains) in 100 cc of starch water given by rectum every six to twelve hours

Elimination—Soapsuds enema

Hypertension—Sedation especially barbiturates and chloral hydrate

Renal and Cerebral Symptoms—The intravenous injection of from 500 to 1000 cc of a 20 per cent glucose solution two or three times daily given within forty to sixty minutes Sufficient glucose is injected to insure a urinary

volume of at least 30 cc per hour. A 30 per cent (500 to 1000 cc) or 50 per cent (200 to 400 cc) solution is used if an adequate output of urine cannot be produced with the 20 per cent solution or if symptoms and signs of pulmonary edema appear. Normal saline, Ringer's and bicarbonate solutions are *contraindicated*.

Pregnancy—If the patient is in labor, delivery may be hastened by rupture of the membranes or the use of a bag. If the patient is not in labor, we may, after a diuresis has been established, consider

A. Induction of labor as described above or

B. Cesarean section. This operative procedure should be performed only if the case is of the severe type or if cephalopelvic disproportion exists. Local anesthesia should be used and the environment must be suitable.

Diet—Nothing is given by mouth until the patient is conscious. As soon as the stomach is emptying itself, 50 cc of a 10 per cent karo syrup solution is injected through a nasal tube and increased 50 cc every hour up to the patient's tolerance (usually 200 cc) and continued until the patient is conscious and able to take water and fruit juices by mouth.

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THE MANAGEMENT OF THREATENED ABORTION

PHILIP F SCHNEIDER M.D., F.A.C.S

ABNORMAL uterine bleeding with or without cramping when encountered in the woman with reproductive capabilities must always suggest to the clinician the possibility of pregnancy with threat to abort. Prior to the advent of the biologic tests for pregnancy (the Aschheim Zondei test and its modifications) it was impossible in many instances to differentiate between early pregnancy with threat to abort and uterine bleeding associated with other menstrual irregularities. The general availability and accuracy of these pregnancy tests have made it possible in most instances to establish a definite diagnosis of pregnancy and to eliminate long periods of uncertainty, enforced inactivity and extremely costly therapy when no pregnancy exists.

The estimate made by Taussig¹ that of the 600,000 to 700,000 abortions which occur annually in the United States only about 30 per cent are spontaneous emphasizes the importance of careful investigation in each case as to the possibility of previous attempted abortion either by the patient or by the professional abortionist.

DIAGNOSIS

In the actual management of the patient who presents herself to the clinician with the symptoms of threatened abortion recent developments in the field of endocrinology must not be considered as a panacea but must be utilized as a valuable adjunct to the conservative methods which have been developed. Despite the fact that the evidence indicates that the greatest number of abortions may be due to endocrine deficiencies it must be emphasized that a constant and important minority are definitely known to be due to constitutional and mechanical causes not involving the endocrine system. It

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is consequently necessary that a comprehensive investigation be made in each instance and that the possibility of the development of unfavorable sequelae should always receive consideration.

After bed rest has been instituted a detailed *history* and careful *physical examination* are essential primarily in establishing the diagnosis of pregnancy and eliminating constitutional disease as an etiologic factor. Careful rectal examination when vaginal examination is contraindicated may be of assistance not only in confirming the diagnosis of pregnancy but also in revealing the presence of uterine malpositions, cysts, fibroids, pelvic inflammatory disease or tubal pregnancy. Pulse rate, temperature levels and leukocytic reactions in view of the reluctance of most patients to admit attempts at interference are of extreme value in differentiating between induced and spontaneous abortion and between septic and relatively aseptic vaginal and uterine tracts. A Kahn or Wassermann test is required in most states during pregnancy and if taken at this time may occasionally reveal luetic infection as the cause of abortion.

If the diagnosis of pregnancy cannot be established from the history and physical findings a catheterized specimen of urine for *biologic test for pregnancy* frequently provides valuable information. A normal active response in the ovary of the rabbit not only establishes diagnosis of the pregnancy but it is presumptive evidence that the embryo is still living. Total absence of reaction may mean that the pregnancy either has never existed or that death of the embryo has occurred. This interpretation however must be used guardedly. The author has observed two cases in which threat to abort (at three months and four months respectively) was accompanied by a complete but only temporary absence of the pregnancy reaction. In each instance the pregnancy reaction returned to normal with the cessation of cramping and bleeding and the pregnancies were carried successfully to term.

GENERAL MANAGEMENT

The amount of bleeding and the severity of the cramping are the best immediate indications as to the inevitability of the

loss of the pregnancy. Bleeding in excess of compatibility with maternal safety with or without severe cramping usually necessitates therapeutic measures incompatible with prolongation of the pregnancy even in the occasional instance where the embryo may still be intact and living. The report of Witherspoon³ of a mortality rate of 9 per cent resulting from operative interference, in contrast to total absence of mortality in an equal number of cases treated without operative interference substantiates the general realization that *with conservative management spontaneous evacuation of the uterus will occur in most instances*. The practice of the immediate injection of morphine pantopon or other narcotics at the first evidence of bleeding and uterine cramping in early pregnancy has fallen into disrepute as a result of evidence indicating that these substances at times *enhance* rather than inhibit uterine motility.

When bleeding becomes sufficiently severe to justify disregard for the integrity of the embryo *pitocin* or some form of the oxytocic principle of the posterior pituitary may be given parenterally supplemented by *ergotrate* intramuscularly intravenously or orally in adequate amounts to control bleeding. Usually 1 cc of *pitocin* intramuscularly accompanied by the administration of $\frac{1}{16}$ grain of *ergotrate* intravenously and followed by the oral administration of $\frac{1}{2}$ 0-grain tablets every four to six hours is sufficient to control the bleeding and effect spontaneous evacuation of the uterus within twenty-four to forty eight hours. Excessive pain due to cramping may under these conditions be controlled with morphine or pantopon as required. It is only in the occasional individual that hemorrhage cannot be controlled in this manner and that operative interference directed toward evacuation of the uterus becomes imperative. Early *transfusion* in the event of excessive blood loss is of importance to the immediate welfare of the patient and may be beneficial in combating the increased incidence of infection which accompanies operative intervention.

Complete spontaneous evacuation of the uterus is usually followed by cessation of cramping and bleeding at which time all oxytocics and narcotics may be discontinued. Failure

of complete evacuation with *retention of decidua* tissue usually results in continued bleeding with or without intermittent cramping. Continued administration of ergotrate and the administration of estrogenic substances will in most instances be all that is necessary to promote spontaneous emptying of the uterus. Continued moderate bleeding with or without cramping for longer than forty eight hours after the evacuation of a major portion of the products of conception is invariably an indication that some remnants of decidua tissue have been retained and for economic reasons may in certain instances in the absence of evidence of infection be accepted as indication for operative interference.

Missed abortion as indicated by a previous positive diagnosis of pregnancy followed by disappearance of the pregnancy reaction and cessation of growth or regression in size of the uterus unaccompanied by bleeding is best treated by conservative measures. A policy of watchful expectancy is usually rewarded by the spontaneous evacuation of the uterus accompanied by a minimum of bleeding and cramping. During the interim between death of the embryo and eventual evacuation of the uterus or the return of the normal menstrual cycle the patient should be under constant observation directed particularly toward the early recognition of the development of hydatid mole or chorionepithelioma. In this type of abortion the administration of estrogenic substances has also been suggested as an effective means of promoting evacuation of the uterus.

The presence of *elevation of temperature and pulse rate* accompanied by *leukocytosis* in threatened abortion while not always conclusive evidence of previous invasion of the uterine cavity is with few exceptions an indication of *infection of the birth canal* and a contraindication to operative interference unless excessive bleeding cannot be controlled in any other manner. Every attempt should be made to control hemorrhage and pain by means of oxytocics, ergotrate and narcotics. The intelligent use of sulfonamides and repeated blood transfusions if necessary are recognized as the most effective measures of combating sepsis and in the event that operative interference is necessary because of prolonged and

moderate bleeding, ten days of normal temperature accompanied by return of the white count and sedimentation rate to normal should be accepted as the only acceptable criterion for such interference. If *excessive* bleeding continues in spite of all possible conservative measures and the immediate welfare of the patient demands operative interference despite evidence of sepsis in the birth canal, evacuation of the uterus should be carried out as gently and as rapidly as possible and a uterine pack inserted. All possible methods to combat the infection should be used and the packing removed in from twelve to twenty four hours. In the presence of infection the continued administration of the oxytocics may be of value.

ENDOCRINE FACTORS

Since this presentation mainly concerns the management of the smaller group as represented by the 30 per cent of cases in which the threat to abort occurs spontaneously, general consideration must be given primarily to our present knowledge of the etiologic factors in this particular group. The consensus of most authorities indicates that the greatest single factor in spontaneous abortion is *developmental defect of the ovum and its appendages*. Irving⁴ has reported from an exhaustive study of specimens that in 70 per cent of spontaneous abortions such defects of the ovum or its appendages were found; in the remaining 30 per cent the evidence suggested maternal defects in 17 per cent thus leaving only 13 per cent in this particular series in which abortion might conceivably have been prevented. The discouraging prognosis indicated by the above report, although distinctly valuable in emphasizing the difficulties confronting us, is somewhat mitigated by the realization that these figures represent only those specimens obtained as a result of abortion and give no information as to the number of threatened abortions in the same group of pregnancies which are successfully carried to term.

Previous concepts of the primary cause of fetal abnormality predicated essential abnormalities of either the ovum or the sperm. Fortunately, more recent observations offer at least presumptive evidence that *lack of a normal endometrium* may be the most important cause of embryonic death or maldevelopment.

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opment and may consequently be one of the most important factors in the prevention of abortion. Greenhill's⁵ report of the marked increase in fetal abnormalities in placenta praevia and Mall's⁶ report that 96 per cent of ova obtained from tubal pregnancy showed evidence of abnormality seem to substantiate this contention.

Purification, isolation and standardization of the estrogens and progesterone and the development of methods of assay of these substances have increased our knowledge of the physiology of menstruation and reproduction appreciably. It has been established that one of the chief functions of the ovarian hormones, estrin and progesterone, is the preparation of a nidatory endometrium. The estrogenic substance is responsible for the development of a proliferative endometrium while ovulation followed by corpus luteum formation provides the progesterone action on the *estrogen prepared* endometrium which results in the secretory or nidatory endometrium necessary for the implantation and development of the fertilized ovum.

Progesterone

When progesterone was first suggested as of possible value in the prevention of abortion on the basis of its inhibiting action on uterine contractions, the possibility of an increase in the number of fetal abnormalities carried to term received fearful consideration. The absence of such increased incidence of malformation in the numerous series reported has been observed with considerable relief and lends support to the theory that in addition to its inhibiting effect on uterine contractions, progesterone possibly exercises an even more important function by a beneficial effect on the endometrium.

As a result of the observations of Falls, Krohn and Lackner^{7, 8} that progesterone inhibits uterine motility in the post partum uterus of the human, progesterone has for the past seven years been accepted and used as a specific in the treatment of threatened and habitual abortion. Essentially in most reports the results of therapy have been much more successful in the treatment of habitual abortion when therapy has been started prior to threat to abort than in the treatment of

threatened abortion when therapy was not instituted until after bleeding and cramping had occurred. Because of the rather frequent failures of progesterone therapy in threatened abortion its merits have been questioned by many. However when we consider that in many instances death of the embryo may have occurred prior to the manifestations of threat to abort, the explanation of the relatively poor results becomes obvious. The inference to be derived in regard to threatened abortion would seem to be that although a poor prognosis exists, adequate therapy should not be denied those patients in whom destruction of the embryo has not been ascertained. More adequate methods of proper selection of cases, when available, should improve the results.

Numerous series of cases have been reported since 1932 in which progesterone has been used either as the sole therapeutic measure or in combination with vitamin and thyroid therapy. The importance of thyroid function in sterility and abortion has been indicated by the work of Litzenberg⁹ and with the increasing evidence of the relationship between the various components of the endocrine system to threatened abortion his observations become increasingly significant. Evidence has also been accumulated which suggests an interrelationship between the endocrines, the vitamins and the minerals and directs attention to the work of Shute¹⁰ stressing the role of vitamin E and to the recent observations as to the role of vitamins C and K. It is of interest that despite many individual spectacular results obtained with thyroid and vitamin therapy much more consistent results have been possible since the ovarian hormones have been used.

Because of the difficulty in establishing the need for the various vitamins and in ascertaining those instances in which thyroid therapy will be of direct benefit a combined method of therapy has been advocated in which *vitamin E* and *thyroid* are administered in conjunction with the progesterone therapy. Collins and Weed¹¹ in their excellent summary of the problem have submitted evidence indicating the value of such combined therapy. Kotz, Parker and Kaufman¹ have recently reviewed the literature and tabulated these various reports in addition to reporting the results in a series of 226

personal cases in which they had used progesterone in conjunction with thyroid and vitamin E therapy

The series of cases reported by Kotz and his collaborators is by far the largest of any series reported to date and the results obtained with progesterone therapy are characteristically illustrative of those which have been previously reported as indicated in Tables 1, 2 and 3. For a com-

TABLE 1
HABITUAL ABORTION TREATED WITH PROGESTERONE

	No. of Cases	Successful	Aborted
Previously reported literature	273	216 (79%)	57 (21%)
Kotz et al	42	37 (88%)	5 (12%)
Total	315	253 (80.2%)	62 (19.8%)

TABLE 2
THREATENED ABORTION TREATED WITH PROGESTERONE

	No. of Cases	Successful	Aborted
Previously reported literature	69	57 (82.6%)	12 (17.4%)
Kotz et al	139	74 (53%)	65 (47%)
Total	208	131 (63.9%)	77 (36.1%)

TABLE 3
THREATENED ABORTION WITHOUT PROGESTERONE THERAPY

	No. of Cases	Successful	Aborted
Kotz et al	45	28 (62%)	17 (38%)

plete analysis the reader is referred to the publication of Kotz and his associates but for the purpose of this presentation it is sufficient to call attention to certain conclusions which the authors have emphasized namely that (1) results with prophylactic progesterone therapy in habitual abortion have been more consistent than those in threatened abortion (2) in patients becoming pregnant after treatment for sterility the danger of abortion is increased (3) the incidence

of premature labor and fetal abnormality is greater than the normal expectancy when bleeding occurs during pregnancy (4) no appreciable increase in the incidence of fetal abnormality was encountered as the result of progesterone therapy

In spite of the superiority of prophylactic therapy in contrast to therapy instituted only after threat to abort has manifested itself consideration of the results leaves much to be desired and suggests that progesterone therapy alone may not provide the ultimate in possible accomplishment in the treatment or prevention of abortion

Krohn and Harris¹³ have reported a series of cases in which oral *pregnenolone* in the form of Pranone (anhydro hydroxy progesterone) (Schering Corporation) was used in

TABLE 4

ORAL PREGNENOLONE IN THREATENED AND HABITUAL ABORTION

	No of Cases	Successes	Failures	Per Cent Successful
Threatened abortion	39	32	7	82
Habitual abortion	11	10	1	91
6 of these patients threatened to abort during present pregnancy				
Total	50	42	8	84

stead of parenteral progesterone (Table 4) The results obtained 82 per cent of successes in threatened abortion and 91 per cent of successes in habitual abortion, are somewhat better than most of the results obtained when progesterone has been used parenterally It is of interest and possible significance that Emmens and Parkes¹⁴ have demonstrated that oral *pregnenolone* in addition to its progestational activity also produced estrogenic stimulation in the rat vagina and that Burge¹⁵ has substantiated these findings in experimental animals and presented additional evidence that *pregnenolone* and progesterone are not biologically identical The possibility of an estrogenic effect as a factor in the clinical results must be considered

The recent report of Falls¹⁶ on the improved results ob

tained in abortion by the use of *corpus luteum extract* in contrast to those obtained with progesterone preparations is also of interest. Due to the fact that this substance is not a pure extraction product of the corpora lutea of animals the possibility of the presence of *small amounts* of estrogenic substance must be considered as a factor in the improved clinical results and suggests an interesting problem for investigation.

Some skepticism as to the necessity or advisability of progesterone therapy in every instance of threatened or habitual abortion has resulted from the apparent *exaggeration of bleeding and cramping* following the administration of progesterone in the occasional patient. Such experiences have been responsible for the conviction that progesterone has increased rather than decreased the tendency to abort in those patients in whom this manifestation was observed. The author has encountered such reactions in a considerable number of cases and has suggested as the cause that either excessive dosages were administered or that progesterone may have been entirely contraindicated in these particular patients.

The *dosages* of progesterone used at present have been almost entirely empirical. Experimental evidence obtained by the effect of its administration on uterine motility in the *normal* patient and evidence obtained from urinary pregnandiol determinations have been utilized in the attempt to determine physiologic dosage requirements. Smith and Smith and Brown and Venning have demonstrated that rise in urinary excretion levels of pregnandiol occur only after the administration of massive dosages of progesterone. If this later observation is used as the criteria of physiologic dosage requirements adequate therapy will be economically impossible in the average patient. Hamblen¹⁷ after extensive experience with urinary pregnandiol determinations states that the studies of urinary titers of the pregnandiol complex are of no clinical value in the diagnosis or treatment of impending or habitual abortion and that patients may threaten to abort when pregnandiol titers are normal. He also suggests the possibility that large doses of progesterone may precipitate abortion by depressing the metabolism of intrinsic progesterone.

Estrogens

That progesterone may not always be the sole ovarian factor in abortion is strongly suggested by our increasing knowledge of the role of the estrogens in the development of the normal endometrium. On the assumption that a normal proliferative endometrium must be present before adequate amounts of progesterone can produce a normal secretory endometrium, it seems possible that in the absence of a normal production of estrogens an adequate proliferative endometrium may not be available and even normal amounts of progesterone will not produce a normal secretory endometrium. This observation suggests the possibility that in some instances the basic deficiency may be of the estrogens rather than of progesterone.

TABLE 5

COMPARISON OF RESULTS WITH ESTROGEN AND WITH PROGESTERONE

	No of Cases	Successes		Failures	Incomplete
		Estrogens	Progesterone		
Habitual abortion	16	9	7	0	0
Threatened abortion	24	1	5	11	1
Total	40	16	12	11	1

Increasing evidence supporting these theories is slowly accumulating. In two recent publications^{18, 19} the author has presented assay and clinical evidence which suggests that normal menstrual and reproductive function is dependent on normal balance between the estrogens and progesterone and that normal balance is of greater significance than quantitative production. In the small series of cases of threatened and habitual abortion which were presented (Table 5) it will be observed that of the sixteen cases of habitual abortion treated prophylactically in whom two or more previous pregnancies had been lost nine were treated successfully with estrogenic substance and seven with progesterone. Of twenty four cases in which therapy was not started until threat to abort oc-

curred only seven cases were successfully carried to term with estrogenic therapy and five with progesterone while the remaining twelve cases aborted. No fetal abnormalities were encountered in any of the cases which were successfully carried to term.

It is of interest to note that in both series more cases were carried successfully to term with estrogenic therapy than with progesterone therapy. Despite the small number of cases involved the fact that no failures occurred in the prophylactic series and that no malformations were encountered in the successfully treated patients in either group may be additional evidence of the role of the endometrium in abnormal development of the fertilized ovum.

Vaginal Smear as a Diagnostic Measure and for Determination of Dosage

Since these statistics were compiled the conclusions arrived at as a result of assay and clinical observation have been further substantiated by means of the vaginal smear stained according to the original technique suggested by Papanicolaou. A much larger series of cases of threatened and habitual abortion have been treated with comparable results. Determination of the type of deficiencies, i.e. estrogen or progesterone which exists and of dosage requirements in each individual have been greatly facilitated by a variation in the interpretation of the vaginal smear which will be described in a subsequent publication. At present however it may be stated that by both clinical and vaginal smear criteria the indications are that true physiologic results are best obtained by means of *small dosages* of either the estrogens or progesterone depending upon the existing deficiency. Excessive dosages of either substance are usually capable of producing extreme exaggeration of the same symptoms which existed as a result of the original deficiency. In estrogenic therapy oral administration has produced more consistent results and has been found to permit a more uniform stabilization of dosage than can be obtained with parenteral therapy. Average daily dosage requirements have been found to be less than 240 day oral units of Collip's emmenin. Continued administration of adequate amounts results in steadily decreasing therapeutic

requirements and necessitates corresponding reduction of therapy until a maintenance dosage has been established in each individual. In progesterone deficiencies the maximum requirements have rarely exceeded $\frac{1}{40}$ mg of proluton (Schering) and even these small amounts are necessary only at infrequent intervals.

It has also been observed that excessive dosages of either the estrogens or progesterone (as evaluated by the vaginal smear interpretation) usually are capable of producing extreme exaggeration of the same symptoms which existed as a result of the original deficiency. *Exact* dosages are necessary to obtain maximum results. These observations suggest that many of our failures in the treatment of that group of threatened and habitual abortions which are due to endocrine deficiencies may be eliminated with the development of the vaginal smear as a diagnostic measure and as an accurate method for determination of dosage.

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curred only seven cases were successfully carried to term with estrogenic therapy and five with progesterone while the remaining twelve cases aborted. No fetal abnormalities were encountered in any of the cases which were successfully carried to term.

It is of interest to note that in both series more cases were carried successfully to term with estrogenic therapy than with progesterone therapy. Despite the small number of cases involved the fact that no failures occurred in the prophylactic series and that no malformations were encountered in the successfully treated patients in either group may be additional evidence of the role of the endometrium in abnormal development of the fertilized ovum.

Vaginal Smear as a Diagnostic Measure and for Determination of Dosage

Since these statistics were compiled the conclusions arrived at as a result of assay and clinical observation have been further substantiated by means of the vaginal smear stained according to the original technic suggested by Papanicolaou.¹ A much larger series of cases of threatened and habitual abortion have been treated with comparable results. Determination of the type of deficiencies, i.e. estrogen or progesterone which exists and of dosage requirements in each individual have been greatly facilitated by a variation in the interpretation of the vaginal smear which will be described in a subsequent publication. At present however it may be stated that by both clinical and vaginal smear criteria the indications are that true physiologic results are best obtained by means of *small dosages* of either the estrogens or progesterone depending upon the existing deficiency. Excessive dosages of either substance are usually capable of producing extreme exaggeration of the same symptoms which existed as a result of the original deficiency. In estrogenic therapy, oral administration has produced more consistent results and has been found to permit a more uniform stabilization of dosage than can be obtained with parenteral therapy. Average daily dosage requirements have been found to be less than 240 dry oral units of Collip's emmenin. Continued administration of adequate amounts results in steadily decreasing therapeutic

PREGNANCY IN THE CARDIAC

LESTER E. FRANKENTHAL, Jr. M.D. F.A.C.S.†

THE treatment of the cardiac during pregnancy and labor has been completely altered in the last twenty years because we now consider the pregnancy as a complication of the cardiac condition. Even with our present knowledge of the subject, however, not only the immediate but also the remote prognosis is very uncertain. In order to approach the problem correctly and to better the prognosis there must be complete cooperation between the cardiologist and the obstetrician.

The reported incidence of cardiac conditions in pregnancy varies from 0.16 to 4.15 per cent with an average of 1.5 to 2 per cent.

The criteria upon which the diagnosis is based are (1) diastolic murmurs (2) cardiac enlargement (3) arrhythmias and (4) history or signs of cardiac failure. It is true that in the vast majority of cases the first two criteria are the ones most frequently encountered and the latter two are almost always found in conjunction with the first two.

Should the cardiac become pregnant? This of course is a difficult question to answer. Much has been written on this subject and yet it is impossible to set down any fast rule which will allow the physician to state that one cardiac may become pregnant and another may not.

Of one thing we are certain and that is that all cardiacs whether pregnant or not should be under the care of a physi-

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cian. The importance of reporting for routine check ups should be impressed on them. When such visits are made, the advisability of their becoming pregnant can be fully discussed with them and their chances of surviving a pregnancy explained. The girl who gives a history of repeated cardiac decompensations or whose heart is fibrillating presents a very bad prognosis and should be so told. On the other hand though the patient with only a mitral stenosis and no history of congestive heart failure or arrhythmia still has not as good a chance of survival as the patient with a normal heart she is infinitely better off than the one who has experienced congestive failure.

MANAGEMENT OF THE PREGNANT CARDIAC PATIENT

Therapeutic Abortion

The incidence of therapeutic abortion in cardiacs has been greatly decreased in the last two decades. This decrease is undoubtedly due to two causes: (1) we know that an abortion even in early pregnancy is a very hazardous procedure from the cardiac standpoint and (2) education of the severe cardiacs and modern birth control measures have greatly reduced the number of cardiacs with poor prognoses who become pregnant. Women with severe heart disease still do become pregnant however and then the physician is faced with a serious problem. Unfortunately we again have no yardstick by which we can be guided. Any manipulation in such a case involves grave risk and therefore should be avoided. If the patient has become pregnant fully aware of the risk she is running and still elects to continue the pregnancy she should be treated as outlined later. If on the other hand she has become pregnant unaware of the seriousness of her cardiac condition and its relatively poor prognosis her cardiac condition must be treated until the optimum response is obtained before emptying the uterus. The best method of delivering such a cardiac is by abdominal hysterotomy. Occasionally a complicating infection arises early in the pregnancy that jeopardizes the life of the patient. Here likewise a therapeutic abortion is indicated. With good health restored a future pregnancy might be attempted with much less risk.

Methods to Prevent Cardiac Failure in the Patient Who Is to Be Carried to Term

In addition to the usual prenatal care, the cardiac patient should be carefully studied and her heart condition evaluated. The goal for which we strive is that there shall be no break in the compensation of the heart during the pregnancy.

At the first visit a thorough physical examination should be made. Special emphasis should be placed upon the finding of foci of infection. When found they should be eradicated as soon as possible. For example, if the teeth are in bad condition cavities should be filled and extractions performed if necessary. In the latter instance we believe it best to have this procedure carried out at home or in the hospital where the patient will spend two nights so that the increased burden of traveling to and from the dental office will not be added to the process of extraction. I cannot overemphasize the importance of eradicating foci of infection so as to prevent if possible the chance of an intercurrent infection during the pregnancy which would only add to the load the damaged heart must carry.

Laboratory examination of the blood and urine should be undertaken. Positive serologic findings naturally call for specific treatment. Anemias are not infrequently encountered and, if early treatment is instituted, difficulty later in the pregnancy can be avoided. Ferrous sulfate in 2 to 5 grain capsules four times a day will suffice in most instances. Examination of the urine may disclose the presence of a reducing agent. A differential diagnosis between glucose and lactose (milk sugar) should be made and this can be done easily by the fermentation test. If glucose is found a dietary regimen may be all that is necessary while in more severe cases the use of insulin may be indicated. Pus in the urine points to a urinary tract infection which in our hands responds very nicely to sulfathiazole in 7.5 grain doses four times a day until the urine clears.

Another important observation to be made at the first examination is the *weight* of the patient. If she is too obese it is advisable to put her on a diet from the beginning of pregnancy. Usually the elimination of fats such as sauces, butter,

cream, soda fountain drinks, ice cream and candy will suffice. However, if subsequent examination shows that the patient continues to gain, a more rigid diet restricted to 1000 calories a day should be enforced. My patients during pregnancy are allowed a maximum gain of 15 to 20 pounds, especially is this true of the cardiacs. In some of the cases of obesity weight is actually lost. However, in one's zest to keep down the weight of these patients, the importance of the well balanced diet must not be overlooked—well balanced not only so far as fat, carbohydrate and protein are concerned, but also in mineral salts and vitamins. An adequate ingestion of vitamins may be assured by the inclusion in the diet of plenty of fresh vegetables and fruits (preferably uncooked) and the judicious administration of vitamin preparations. Fruit juices and milk should be taken in moderate amounts. They, along with other fluids, are best taken between meals so as not to overdistend the stomach. This plan should be followed in all cases of cardiac disease, but especially during pregnancy.

At her first visit a daily regimen should be outlined for the patient. She should be made fully cognizant of her cardiac condition in order to enlist her cooperation. It should be emphasized that as soon as any illness or untoward symptom occurs she must immediately go to bed and call the physician; his troublesome complications may be avoided.

Rest is likewise most important for the cardiac during pregnancy; a minimum of eight to ten hours in bed each night is essential. Likewise an hour's rest every afternoon should be enforced. During the afternoon period the patient need not of necessity sleep, but she should be alone so that quiet is assured.

Limitation of exercise should be impressed upon the patient. This not only includes the unnecessary climbing of stairs, but also outside walks. She should be instructed to limit her exercise to the necessary activities attendant upon her usual household duties, and should take outdoor exercise only under the express permission or instruction of the attending physician. Women who are working should be instructed to continue to do so if the work is of the sedentary type, such as typing or secretarial work. However, if the patient's work

is more active (such as salesgirl) she should be advised to stop working or attempt to find a less strenuous occupation. The housewife who is unable to take care of her household duties may find it necessary to get some member of the family or a paid housekeeper to assume these duties.

Periodic examinations should be insisted upon by the physician. Up to the sixth month of pregnancy the patient should report to the doctor's office every two weeks whether or not she thinks it necessary. In this way any of the signs of heart failure may be observed early. Even the subclinical sign of rales at the bases posteriorly may be detected. During the sixth, seventh and eighth months of pregnancy when the load on the heart is greatest she should report every week. It is likewise important to emphasize to the patient that if she has any unusual symptoms between visits to the physician she should report them immediately. Again to reiterate I must emphasize the fact that the cardiac during pregnancy should be in constant touch with her physician.

Treatment of Established Congestive Heart Failure

The foregoing remarks have outlined the methods most generally employed to prevent cardiac failure but in spite of these precautions it may occur. Therefore the next important step is to attempt to recognize failure as early as possible.

The first symptoms are (1) attacks of dyspnea (2) substernal or anginal pains and (3) moist rales at the bases of the lungs posteriorly.

Following these symptoms the more classic ones develop (1) hemoptysis (2) congestion of the veins of the neck (3) passive congestion of the liver as evidenced by increased dullness and palpation of the liver below the level of the ribs, (4) generalized edema and in advanced cases abdominal and pleural effusions and (5) auricular fibrillation. Vigorous treatment must now be instituted.

The patient must be immediately put at *absolute bed rest*, preferably in a hospital. Competent nursing should be made available so as to relieve the patient of as much exertion as possible namely turning in bed and feeding herself. A back rest or an arrangement of the pillows so as to elevate the head

greatly relieves the breathing difficulty. Care should be taken to elevate the chest as well as the head so that the head does not become flexed on the chest thus impeding respiration. *Sedatives* must be administered barbiturates in the milder cases (phenobarbital grains $1\frac{1}{2}$ every two hours for two doses and then four times daily) and in the more severe cases opiates should be given (morphine sulfate grain $\frac{1}{4}$ as indicated).

Digitalis should be started immediately. In severe cases it should be given intravenously to obtain digitalization as quickly as possible. It has been our experience that when digitalis is once started during pregnancy it is usually necessary to continue it until after delivery. Also we never give digitalis to a cardiac in the hope of avoiding decompensation.

Diet and fluid intake must be closely watched. We at once limit these patients to a quart of fluid each twenty-four hours. As they are allowed only liquids we feel that peptonized milk is best for them since it gives them food as well as fluid. It is given in quantities of 4 to 6 ounces every four hours. Peptonized milk causes less gas formation in the gastrointestinal tract than ordinary milk. This gas formation is to be avoided for added abdominal distention only increases the embarrassment of an already overtaxed respiratory system. As the acute cardiac failure subsides small feedings of solid food are given four times a day and liquids (up to a quart) are allowed between the times of the dry meals.

Care of the bowels is also very important during congestive heart failure. In our experience the use of a mild cathartic (2 ounces of milk of magnesia twice daily) is superior to an enema for the reason that the former involves less effort on the part of the patient. If the patient still has difficulty with an evacuation the insertion of a glycerin suppository into the rectum will usually suffice.

Finally in more advanced cases where the venous congestion is very marked or where fluid is found in either the chest or abdominal cavities *venesection* or *paracentesis* as the case may be is indicated. One very important rule must always be observed and that is that *under no circumstances should an attempt be made to evacuate the uterus by any means while a patient is in congestive heart failure*.

CONDUCT OF LABOR

All cardiacs should be delivered in a hospital and preferably they should be admitted a week or so in advance of labor so that the cardiac condition may be re-evaluated and the patient be given ample rest. Likewise if possible, a cardiologist should be readily available throughout the entire labor. At any rate, a physician should be in attendance throughout the entire labor.

First Stage—Under ideal conditions the cardiac patient will in the vast majority of instances begin her labor with cardiac compensation and with the necessary cardiac reserve. These must be maintained throughout the first stage of labor by the adequate use of morphine or other sedatives or various analgesics. The use of morphine sulfate (grain $\frac{1}{4}$ to $\frac{1}{2}$ is indicated) still furnishes the best means of insuring rest during labor. Morphine is also of inestimable value for resting the damaged heart, and thus its liberal use is doubly indicated for the patient.

Second Stage—A definite amount of muscular effort is required to complete the second stage of labor spontaneously. It is generally considered that the repeated effort of bearing down is too great a strain to place upon an already diseased heart; hence the admonition that the second stage of labor must be eliminated is present in practically every discussion of this subject in the literature. In the abstract this view would seem correct. Since however the amount of muscular work entailed upon the patient in completing the second stage spontaneously is dependent upon a combination of factors such as multiparity, size of the fetus, pelvic measurements and condition of the soft parts, it would not seem judicious to generalize too completely.

If no cephalopelvic disproportion is present the labor should be terminated by forceps as soon as the patient enters the second stage, provided the head is below the level of the ischial spines. When it is at or above this level the patient may be allowed to bear down a few times while under ether analgesia so as to facilitate the forceps delivery.

Third Stage—The third stage of labor carries a small but very definite risk for the cardiac patient. The more or less sudden decrease in intra-abdominal pressure coupled with the

lowering of the diaphragm and the abrupt change in the cardiac axis are all factors which can lead to cardiac collapse. In an attempt to obviate sudden disasters which have been reported in the third stage it has been our routine for many years to place sandbags on the abdomen concurrently with the delivery of the child. Three or four such bags are used and are removed one at a time at fifteen minute intervals.

Anesthesia—The choice of anesthesia in the cardiac is very important. Good relaxation is important in any operative delivery and this must be obtained with the best anesthetic agent available. Ether, either by the drop method or the closed method with adequate oxygen, is usually readily available and has proved after many years of trial to be safe. The induction should be slow and very gradual so as not to cause straining, vomiting or coughing. A skilled anesthetist is desirable. Ethylene in our hands has proved to be very satisfactory although I do not believe it should be recommended because the margin between anesthesia and asphyxia is very narrow. The same holds true for nitrous oxide. On the other hand cyclopropane is of very great value when available because it is administered in a high percentage of oxygen. I do not believe the use of local anesthesia to be of special importance in the cardiac. If for some particular reason it is indicated 1 per cent procaine *without* adrenalin should be used.

Hemorrhage—There is an old belief that a moderate post partum hemorrhage is beneficial to the cardiac patient. This belief probably has its origin in the use of venesection during severe congestive heart failure. I cannot hold to the view that it is beneficial therefore concurrent with the delivery of the shoulders. I give an ampule of ergotrate intravenously. This has reduced the blood loss to a minimum and likewise has in no way affected the incidence of retained or adherent placenta.

Cesarean Section—It is our experience and that of other obstetricians that cesarean section for a cardiac condition per se is not indicated. If there is a definite obstetrical indication such as cephalopelvic disproportion, placenta previa, centris or ablutio placentae then section should be performed as in normal obstetrical practice. The contention that cesi-

mean section takes the added load of labor off the damaged heart is erroneous. As a matter of fact, it adds the load of a labor room with its possible complications (dysrhythmia and so forth) which are usually more severe than a delivery per se.

Another indication that is sometimes advanced for section in the cardiac is sterilization. Here again the matter is still far safer to allow the cardiac to deliver vaginal and then, if future pregnancies are considered undesirable, to have a period of three or four months elapse during which time her cardiac condition will probably improve. At the same time an abdominal sterilization may be done, or in case necessary emergency treatment may be indicated.

Puerperium—Rarely does cardiac failure occur or recur during the puerperium. Nevertheless, the same treatment may be taken during the puerperium as during pregnancy and labor. Complete mental and physical rest should be assured for the patient. If the heart is still decomposed the treatment previously outlined must be continued.

In those cases in which the patient has come through the labor without complications, two weeks of bed rest is indicated. At the end of this time a thorough examination of the heart should be made and the patient allowed out of bed for short periods of time each day. As her condition improves she is then permitted to resume her normal activities gradually.

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rean section takes the added load of labor off the damaged heart is erroneous. As a matter of fact it adds the load of a laparotomy with its possible complications (ileus, sepsis, and so forth) which are usually more severe than a delivery per vaginam.

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OBSTETRICS IN THE HOME*

HENRY BUXBAUM MD FACS†

DESPITE a recent definite trend towards hospitalization of the parturient patient, 50 per cent of the babies born in the United States are still delivered in the home. Thus home obstetrics is an unavoidable necessity and will continue to be so for a long time. Furthermore, it is the consensus of outstanding teachers in the specialty that medical students can be more accurately instructed in the fundamentals of obstetrics at home than in a hospital because here the student must of necessity remain in constant attendance and will therefore have better opportunity to familiarize himself with the mechanism and clinical course of normal as well as abnormal labor.

SPONTANEOUS DELIVERY

Equipment and Set up

The minimum equipment necessary for spontaneous delivery is herewith listed

Razor	One large basin
Head stethoscope	Lubricant
Sterile gauze jar	Ether
Green soap	Obstetric forceps
Sterile cord tie	Sterile uterine packing
Two pairs of good gloves in a bag	Morphine sulfate gr $\frac{1}{8}$ and $\frac{1}{4}$
Two pairs of rectal gloves	Scopolamine gr $\frac{1}{2}$ o
Two small basins	Ergonovine gr $\frac{1}{2}$ o
Ampules of obstetric pituitrin	

The pans gloves instruments and solutions are boiled in the patient's home (Fig 1)

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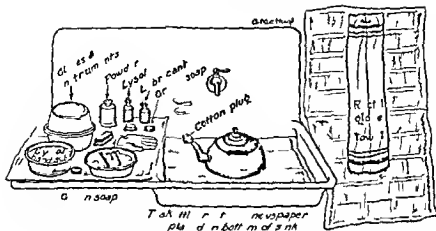


Fig 1—The sink is set up. The taker's instrument and gloves have been sterilized by boiling. Following rectal examination the gloves are discarded, washed, and dried on the rectal glove to el.

Conduct of Labor

Normal deliveries are conducted with the patient lying lengthwise in bed (Fig 2). The operator must be constantly

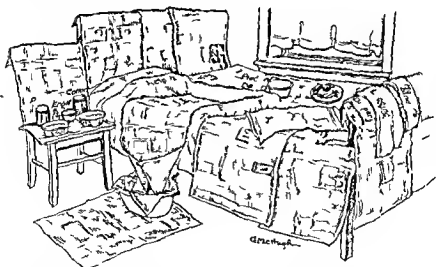


Fig 2—The bed set up is used for normal spontaneous delivery and for emergency operative work when no assistance is available. A pillow pad is made from rolls of newspaper and oil cloth. The patient is delivered lying lengthwise in bed. If operative work is performed, the patient in bed, the roll is removed, the man is placed on the bed, and the feet are supported by two chairs.

aware that everything in the improvised delivery room is contaminated with the possible exception of the immediate operative field i.e. vulva and operator's hands. Sterile gowns are unnecessary and may give a false sense of security. Because of the limited field of asepsis the operator must employ a rigid aseptic technique, after the patient has been shaved

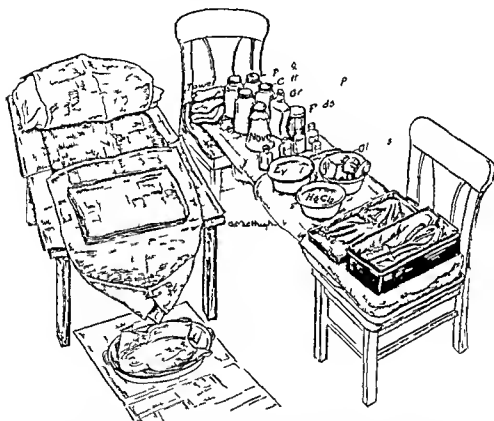


Fig 3.—The operative set up. The kitchen table is padded with blankets and covered with newspapers. The patient is placed upon it in the lithotomy position; the legs are supported either by members of the family or by stirrups. An ironing board is covered with newspapers and placed between two chairs. It serves as an instrument table.

and the operator is scrubbed for delivery he must touch nothing but the vulva and that only when absolutely necessary.

The patient is placed upon the kitchen table prepared as shown in Figure 3 for operative work.

The progress of the labor can be determined by abdominal palpation and rectal examination. It should be remembered

however that rectal examinations are not wholly without danger and should be kept to a minimum

It is essential that every doctor taking obstetric cases should be thoroughly familiar with the normal mechanism of the third stage of labor. The most significant sign of placental detachment is a change in the shape of the uterus from a globular ovoid to an irregular pear shaped organ with an elevation usually appearing on the right side pointing towards the liver. If the attending obstetrician patiently waits for this rather definite sign he can complete the third stage by simple expression of the placenta with little or no danger to the mother.

If labor has terminated spontaneously all resulting tears or episiotomy incisions should be repaired immediately following completion of the third stage. The simplest method possible should be chosen for repair. Preferably interrupted No. 1 chromic catgut should be used in the vaginal mucosa and figure of 8 silkworm gut in the perineum with no catgut buried.

Before leaving the case after delivery the doctor should make certain that the uterus is well contracted in the midline with all bleeding controlled and that temperature, pulse, respirations and blood pressure of his patient are normal.

Analgesia and Anesthesia

First Stage—Morphine sulfate in doses of $\frac{1}{8}$ to $\frac{1}{4}$ grain is still the safest and best analgesic particularly in home obstetrics. It can be administered either alone or in combination with a synergist such as scopolamine grain $\frac{1}{150}$ or 2 cc of 50 per cent magnesium sulfate. It will give the patient a much needed rest and at the same time will not interfere with cervical dilatation or effacement. However morphine *must not be given* if you expect the baby to be born within three hours and *must not be given* to a woman in labor prematurely in both cases because of its effect upon the child.

The barbiturates are not well adapted for home use because of their possible deleterious effects upon the child because of the frequent necessity for operative interference after the administration of such a drug and because of the maniacal state sometimes induced in the patient.

Second Stage—The second stage can be safely conducted by two methods. First, drop ether may be given to assist the patient in bearing down. This may be administered by a supervised lay assistant but care must be taken that there is no hot stove or open flame in the immediate vicinity. The second and by far the safest method of anesthesia yet devised for home obstetrics is local anesthesia. This can be administered by infiltration, pudendal block, or presacral block. The technic is quite simple, requires no assistants and is perfectly safe. The usual solution used is 1 per cent procaine in distilled water with 2 minims of adrenalin to an ounce of solution. The adrenalin may be omitted if desired.

OBSTETRIC COMPLICATIONS

Incomplete Abortion

Incomplete abortion is successfully handled in the home by *dilatation and curettage*. Inject one ampule of pituitrin into the cervix before starting the operation. Uterine packing is unnecessary if the contents of the uterus have been thoroughly evacuated and it is often dangerous since it may lead to the formation of a pelvic abscess. Meticulous aseptic technic must be employed to decrease the possibilities of a postabortal infection.

Placenta Praevia

Placenta praevia is far better managed in a well equipped hospital than in the home. The consensus today on this complication favors abdominal delivery if the patient is at or near term and if the fetus is alive. But I can visualize instances where it may be a hazardous undertaking to send a patient with placenta praevia to a hospital as when profuse hemorrhage precludes the possibility of safe transportation or when a good hospital with a well equipped maternity is not in the near vicinity. Emergency measures therefore may have to be instituted in the home and I shall attempt to outline the treatment as I have used it on rare occasions in the home.

1 *Control of Hemorrhage*—Hemorrhage may be controlled by one of four methods.

(a) Simple *rupture of the membranes* will often suffice especially in the lateral or marginal types.

(b) An *intra ovular bag* may be introduced which will act both as a tampon and cervical dilator. A weight consisting of a pint can of water tied to the tubul end of the bag and thrown over a pulley or the rounded foot of the bed is attached to the bag to maintain a constant steady pressure against the low lying placenta. Two definite precautions must be strictly observed when this procedure is adopted. First care should be taken that too much weight is not applied lest too rapid cervical dilatation occurs. Owing to the position of the placenta in the zone of dilatation of the uterus the large uterine sinuses are located in the lower uterine segment. The lower uterine segment and cervix therefore become congested and edematous and the cervix will tear like wet blotting paper if dilatation is too rapid or forced. Lacerations thus produced may easily extend into the base of the placental site and produce fatal hemorrhage. Secondly the physician must remain in constant attendance and not relax his vigilance for one moment for when the bag is expelled from the uterus tension is released and brisk hemorrhage is the rule. The doctor must keep himself in readiness to deliver the patient instantly by the quickest method possible immediately upon expulsion of the bag from the uterine cavity.

(c) The obstetrician may rupture the membranes and bring a foot down through the cervix and into the vagina—the so called *Braxton Hicks version*. This procedure is particularly indicated when the fetus is either previsible or dead. In this method the thigh of the baby acts as both a tampon and cervical dilator. To obtain sufficient relaxation of the fundus so that the version can be performed expeditiously and without danger to the mother it is usually necessary to give the patient deep surgical anesthesia with drop ether. For the same obvious reasons mentioned previously if traction is to be applied to the foot of the baby—and this is not always indicated—the weight should not exceed 1 pound.

(d) Gaining favor recently in the control of hemorrhage in placenta praevia is a method by which the scalp of the baby is grasped with a specially constructed instrument known as the *Willett forceps*. With a pound weight attached this instrument utilizes the head of the baby as a tampon. By keeping

ing the head in constant juxtaposition with the low lying placenta a steady pressure is maintained against the fetal surface of the placenta thereby effectively controlling the bleeding. This method is applicable only in the lateral and marginal types of placenta praevia.

2 *Evacuation of the Uterus*—The method to be employed in emptying the uterus depends almost entirely upon the conditions present in each individual case. To illustrate if the head is engaged and the baby is alive the operation of choice is forceps extraction. If the head is engaged and the baby is dead a craniotomy is indicated. If a Braxton Hicks version was employed to control hemorrhage the subsequent delivery must be completed by a breech extraction. If an intra-ovular bag was the primary procedure and the head is floating the operation indicated is version followed by extraction.

Hemostasis—Immediately upon delivery of the child 1 ampule of obstetric pituitrin is injected subcutaneously and as soon as the placenta is expelled 1/2 to 1 grain of ergonovine is given intravenously. If active bleeding or even oozing continues postpartum it may be good obstetrics to pack the uterus tightly with nonmedicated sterile gauze. To invade the uterus of a recently delivered woman is a dangerous procedure and particularly is this so when she has lost a great deal of blood. The operator must keep this fact in mind when necessity forces him to take this drastic step and employ the most rigid of aseptic techniques.

Replacement of Blood Loss—Lost blood can be effectively replaced by injecting fluids parenterally. Normal saline solution given by hypodermoclysis or by intravenous injection is of value if a more effective solution is not readily available. The intravenous administration of 10 per cent glucose in normal saline solution is also a valuable adjunct in treating primary blood loss. While these methods will serve in an emergency it is not only preferable but also distinctly feasible in home obstetrics to use either whole blood or a blood substitute. This can be made possible by a little preparation and foresight on the part of the physician. He should have previously ascertained where the nearest blood bank is located. If there is one within a reasonable driving distance, he can

send a sample of the patient's blood to the bank for typing and matching and the same messenger can bring back the proper amount of compatible blood. Better still the doctor can carry blood serum or lyophilized plasma in his emergency bag at all times. This administration of blood plasma or serum can be started immediately without typing, matching or even heating. By thus being prepared we may expect to reap the dividend of many lives saved that would otherwise be lost.

Abruptio Placentae

This extremely serious obstetric complication may be treated in the home if circumstances make it absolutely necessary. Ordinarily if the patient is not in labor and the cervix is long, hard and undilated it would be safer to put her in an automobile and rush her to the nearest hospital. On the other hand if the patient is definitely in labor with a partially dilated cervix treatment in the home is indicated and will consist of artificial rupture of the membranes and application of a tight abdominal binder and the administration of 1 to 2 minims of pituitrin. As soon as the cervix is completely dilated the fetus should be extracted by the most expedient method: forceps extraction if the head is engaged, breech extraction if the breech is the presenting part and version if the head is floating. Uterine contractions are stimulated by the hypodermic injection of pituitrin or intravenous ergo novine or both. In the event that bleeding still persists it may be necessary to pack the uterus. The treatment of primary blood loss and shock is the same as outlined previously under *Placenta Praevia*.

Postpartum Hemorrhage

Whenever 500 cc. or more of blood is lost during or after the third stage of labor the case should be considered as one of postpartum hemorrhage. In our experience with home deliveries it is better to overestimate rather than underestimate the amount of blood lost so as to focus the obstetrician's attention on the immediate problem at hand. Treatment should be active and the operator should concentrate all his energy on the welfare of the patient; he should not even allow the

resuscitation of an asphyxiated baby to interfere with or divert his course of action

The *prevention* of postpartum hemorrhage is one of the most important single factors in obstetrics. Inasmuch as mismanagement of the third stage of labor or attempts at too hasty expulsion of the placenta are responsible for the majority of the cases of postpartum hemorrhage, all doctors should refresh their memories from time to time on the mechanism, clinical course and management of the third stage. The most important protective principle involved is to make certain that all the signs of placental detachment are present before any attempt is made to expel the placenta regardless of the time involved.

The *active treatment* consists of catheterization and manual removal of the placenta, if it is still retained, under the most rigid aseptic precautions. If bleeding is due to cervical, vaginal or perineal tears, they should be repaired immediately. If uterine atony is the etiologic factor, the closed fist should be inserted into the lower uterine segment, then with the external hand, the fundus of the uterus is anteflexed acutely over the symphysis pubis. This maneuver will in most instances control the bleeding. One ampule of pituitrin subcutaneously or $\frac{1}{2}$ o grain of ergonovine intravenously is now given. If bleeding still persists it may become necessary to pack the uterine cavity tightly with sterile nonmedicated gauze to be removed eight hours later. I believe it is seldom necessary or even indicated to repack a uterus if the patient continues to bleed through a properly packed uterine cavity; this bleeding in all likelihood is due to an incomplete tear in the lower uterine segment. Should this added complication occur the packing must not be disturbed, the patient is rushed to the nearest hospital where she is given a transfusion and a supracervical hysterectomy is performed.

A *Momberg belt* or a *Spanish windlass* may sometimes be used to control profuse bleeding temporarily until something more permanent can be instituted. These constrictors must not be left on for any length of time since they may interfere with the circulation of the lower extremities, or they may even produce paralysis of the lower extremities by shutting

off the circulation to the spinal cord. Lost blood is replaced by the infusion of saline solution, glucose solution, whole blood or a blood substitute.

Shock

In the treatment of shock the foot of the bed is elevated and warmth is applied to the extremities, taking care not to burn the patient. Hot coffee, retention enemas may be tried. The intravenous administration of fluids should be started as soon as possible in the form of normal salt solution, 20 per cent glucose or 6 per cent dextrose in normal saline solution, the choice depending upon which solution is the most readily available. But I want to emphasize here again that the most effective treatment for this serious complication is the use of whole blood or a blood substitute. Cardiac stimulants as a rule are of little value. The main consideration is to replace fluid loss and restore blood volume.

Prolapse of the Cord

If the fetus is pre-viable or dead, nothing is to be done. If the fetus is viable the patient is placed in the knee chest position and complete dilatation is awaited. If uterine contractions remain severe it may be necessary for the obstetrician to slip on a sterile glove and hold the presenting part above the inlet to prevent compression of the cord. The patient can then be placed under deep surgical ether anesthesia and a version performed.

Eclampsia

Prophylactic Treatment—Every pregnant woman and particularly one who is to be confined at home requires thorough prenatal care. She must be instructed as to the proper foods, garments and exercise. She should visit her physician at least once every three weeks up to the seventh month of pregnancy and once every two weeks thereafter. At each visit her urine, blood pressure and weight gain should be noted. Abdominal palpation is utilized after the seventh month and at her last or prepartum visit a tentative prognosis as to the expected course labor will follow is made on the basis of the

position of the presenting part and its relationship to the inlet of the pelvis. By this conscientious survey during pregnancy it will be possible to note the signs and symptoms of incipient late toxemias and treat them accordingly. In most instances such treatment will prevent the condition from progressing into the convulsive stage.

Active Treatment—The tongue and cheeks are protected with a gauze covered tongue depressor or clothespin. Morphine sulfate grain $\frac{1}{4}$ may be given and repeated in thirty minutes. This form of treatment is abandoned if the respirations decrease to twelve per minute. If convulsions continue 20 cc. of a 10 per cent solution of magnesium sulfate is injected intravenously. As an alternative 10 cc. of a 25 per cent solution may be given deep in the gluteal muscles. Some patients evince an idiosyncrasy to the drug and suffer a mild form of shock with projectile vomiting. The antidote is calcium chloride which should always be near at hand. The administration of magnesium sulfate intravenously can be repeated every four hours for four to six doses if necessary. If a more drastic hypnotic is desired, 7.5 grains of sodium amytal may be given very slowly intravenously.

Upon cessation of the convulsion an infusion of hypertonic glucose is begun. We are in the habit of using 250 cc. of a 20 per cent solution in distilled water repeated three times daily until the urinary output increases perceptibly. I wish to emphasize that distilled water and *not* salt solution is used as the vehicle for the hypertonic glucose because in all late toxemias of pregnancy there is a water imbalance due to the retention of electrolytes. The addition of more sodium chloride will increase the occult as well as the visible edema.

No attempt is made to initiate labor until at least forty-eight hours have elapsed and the patient is conscious, free from convulsions and her urinary output approximates or exceeds her fluid intake.

Resuscitation of the Asphyxiated Infant

Any mucus present in the pharynx is cleared away and the baby is kept warm with towels heated in the oven. His body should be rubbed briskly with a coarse towel after which

he should be immersed in a warm water bath. Every doctor practicing obstetrics should be familiar with the technic of passing a *tracheal catheter*. This simple but life saving procedure can be mastered without a great deal of difficulty by passing the catheter whenever the opportunity arises as in a stillbirth. Stimulants such as coramine, alpha lobeline and adrenalin are of some value but are by no means as effective in reviving an infant with asphyxia *linda* as is the tracheal catheter.

In asphyxia *pallida* which is usually due to a cerebral hemorrhage the treatment is much the same with the addition of intramuscular injections of 20 cc. of whole blood into the gluteal muscles or between the scapulae. Vitamin K to increase the prothrombin level is also recommended.

OPERATIVE OBSTETRICS

Forceps delivery, version, breech extraction, manual removal of the placenta, uterine tamponade and primary perineorrhaphy can be readily and safely performed in the home. *Local anesthesia* is the anesthesia of choice but ether can be employed using a tea strainer as a mask. The technic of administering local anesthesia is quite simple and the results are most gratifying. Any technic that will obviate the necessity of an assistant will completely eliminate the possibility of any postanesthetic pulmonary complications and will allow the patient to retain consciousness through the procedure. It is worth taking the trouble to learn. The outlet forceps operation can be done and perineal repairs made by simple infiltration of the perineum, posterior fourchette and hymenal ring. If necessary, this anesthesia can be augmented by *puddendal block*. Manual rotation, the midforceps operation and even versions can be done (and have been done several hundreds of times at the Chicago Maternity Center) with *pre-sacral anesthesia*. The results have been uniformly good. With this type of anesthesia the uterine contractions will continue but all subjective sense of pain disappears.

The type of obstetrical *forceps* used is unimportant. I am convinced that every doctor should employ the same type of forceps on all forceps cases until he has completely mas-

tered its use and only then should he start to experiment with other types

It is beyond the scope of this paper to discuss the different operative techniques but I cannot refrain at this time from warning every physician who accepts cases for home delivery that he must first ground himself in the diagnosis of obstetrical complications and that he must be at least fairly well acquainted with the simpler operative procedures. Also because of the fact that expert obstetric consultation is often a geographic impossibility it behooves the physician who undertakes to deliver a baby in the home to assist Nature and not supplant her except when his intervention is absolutely necessary to save the mother's or baby's life.

CONCLUSIONS

To substantiate my thesis that obstetrical deliveries can be conducted safely and well in the home I should like to cite briefly the statistics of the Chicago Maternity Center. Since its founding in July 1932 this institution has delivered 26021 babies in the home. Of these 94 per cent delivered spontaneously and only 6 per cent were delivered from below by some operative means. The incidence of operative deliveries could have been further restricted but because we are primarily a teaching institution many cases were terminated operatively for teaching purposes. These figures do not include cases referred to the hospital for cesarean section. Incidentally the abdominal route of delivery was chosen in one out of every 150 deliveries on our service.

Our maternal mortality which includes all patients delivered by us and then dying either at home or in the hospital was 0.10 per cent or ten maternal deaths per 10,000 live births. Several of the twenty-six women who died were tuberculous. The uncorrected fetal mortality was 4 per cent eliminating macerated stillbirths, monsters and babies in which no fetal heart tones were present on arrival of the doctors; the corrected fetal mortality was 1.89 per cent.

I believe that our results can be used as a basis of comparison. Our patients are entirely unselected since we accept any woman who cannot afford to pay for the services of a

private physician. Most of our patients are referred to us by the health department, police and relief agencies. It is therefore quite obvious that our practice is drawn from the slums of a large metropolitan city. It must be realized then that our deliveries are all conducted in the squalor of filthy tenements, in shacks and railroad box cars among the most unsanitary and unhygienic surroundings. In spite of the lack of a clean aseptic delivery room and in spite of the fact that the great majority of our cases are delivered by interns and medical students, our results are very encouraging.

A TECHNIC FOR ADMINISTERING CYCLOPROPANE IN OBSTETRICS

(Based on a Clinical Study of 1392 Cases)

MARY KARP M D

and

GARWOOD C RICHARDSON M D F A C S †

HISTORY

THIS study of cyclopropane anesthesia in obstetrics was begun September 16, 1937 at the Wesley Memorial Hospital. For the first six months of its use cyclopropane was administered by the chief anesthetist and deliveries were performed by the chief obstetrician in an effort to determine the intricacies and dangers if any that might exist in this new anesthetic agent. As a result of its preliminary successful clinical trial the use of cyclopropane was extended to all anesthetists and to both staff and intern deliveries of private and service cases.

In 1937 cyclopropane was administered in 10 to 12 per cent of all deliveries, in 1940 and 1941 at which time this series was completed 98 per cent of all deliveries were aided by this gas.

To merit such widespread gain in favor and usage this anesthetic must possess certain inherent advantages over anesthetics previously employed in obstetrical practice and to maintain such favor it must be devoid of the more serious objections to the older more widely used and known anesthetic agents. Obstetrics has long been in need of an ideal anesthetic one which will provide analgesia when desired proper relaxation for all obstetrical procedures and adequate oxygenation. It appears as a result of this study that cyclopropane is at least an admirable approach to that ideal.

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COMPARISON WITH OTHER AGENTS

An analysis of the deficiencies of our previous anesthetic agents presents certain factors many of which have been common knowledge but a few of which are the result of recent research

Chloroform is capable of producing sudden death by cardiac paralysis or of inducing central necrosis of the lobules of the liver of the mother² and of inducing an albuminoid degeneration of the fetal heart and liver

Ether produces damage to the healthy liver and kidney in the presence of anoxia it is irritating to the respiratory system According to Schumann³ the longer and deeper the anesthesia the more persistent the uterine relaxation and the greater the tendency to postpartum hemorrhage Irving⁴ believes that ether creates renal irritation

Ethylene is an inert gas without toxic properties It is however an inadequate anesthetic in the more major obstetrical procedures where complete relaxation is imperative as in version and cesarean section Too frequently it must be supplemented or replaced by ether Anoxia occurs when one endeavors to extend its use beyond its natural limitations

Nitrous oxide is the least fraught with dangers of an histotoxic nature as compared with chloroform ether and ethylene but physically it is the most self limited It provides the least latitude for operative procedures requiring relaxation and when extended in its limitations provides the greatest anoxia The histologic damage done by nitrous oxide and ethylene is not due to the gases themselves but to the anoxia which occurs when they are employed for procedures too major for their adaptability This anoxia may cause permanent tissue damage or prove fatal to mother or infant or both

TECHNIC

In the 1392 cases herein discussed the following technic for administering cyclopropane was employed This technic is for use in the case of the average healthy mother The dosage in the final analysis must depend on varying factors such as the metabolic requirements of the patient premedica

tion received and risk. It must accordingly be altered for the individual case. It is important to observe closely the reactions of the drugs used, and to adjust properly the various gases in order to maintain the desired plane of anesthesia.

A carbon dioxide absorption method is used for all cyclopropane administrations.

Helium is added to lighten the anesthetic mixture and to aid in the prevention of explosions.³ This does not obviate the necessity for careful adherence to the other precautions used in avoiding explosions, such as conductive rubber parts grounding and constant contact.

In the last few months we have been giving atropine sulfate gram $\frac{1}{150}$ subcutaneously to all patients when they are brought to the delivery room. We feel that this precaution has reduced the amount of salivation and laryngospasm.

For Analgesia

The bag (4 to 6 liters) is filled with a mixture of cyclopropane, oxygen and helium at the rate of 300 cc, 500 cc, and 700 cc per minute respectively. Soda lime canister is turned into the system. As soon as the patient complains of beginning contraction, the mask is placed on her face and she is asked to 'take three deep breaths,' and to 'hold the third and bear down.' If the patient tends to drowse through her rest periods between pains or becomes momentarily unconscious the number of inhalations of the cyclopropane mixture is reduced. For a subsequent pain she is asked to take two breaths holding the second as she pushes. If this dose is still too heavy (and it may be if the patient has been given any of the barbiturates) the number of inhalations is reduced to one. By this manner in a period of four or five pains the anesthetist quickly becomes acquainted with the patient's tolerance to the anesthetic and can keep her free from distress for the remainder of the first stage and into the second stage of labor.

If care is exercised so that the patient exhales into the bag before taking her first breath of cyclopropane mixture and after she has had her last bearing down impulse of the contraction one 4- to 6 liter bag with the above concentration of cyclopropane will give pain relief for from four to six con-

tractions. Then it will be necessary to add more cyclopropane in the proportions stated above.

For Episiotomy

The patient is instructed to take seven deep breaths as soon as her next pain begins and to hold the eighth breath as she bears down. The anesthetic mixture is changed so that cyclopropane is added at 700 cc per minute, oxygen at 500 cc per minute and helium at 1000 cc per minute. This mixture will be sufficient in most cases to give the patient a complete analgesia or momentary loss of consciousness without loss of the bearing down impulse; there will be adequate time for a careful episiotomy. The mask is then removed from the patient's face; the patient is allowed to awaken and to strain with her next contraction to aid the obstetrician in the delivery of the head.

Second Stage

When the obstetrician has a firm control of the oncoming head as with a Ritkin maneuver, preferring to deliver the baby without the voluntary expulsive movements of the mother, the anesthetist instructs the patient to refrain from pushing, to breathe the gas deeply. The gases are set as for the episiotomy: cyclopropane running at 700 cc per minute, oxygen at 500 cc per minute and helium at 1000 cc per minute. In a few breaths the patient is unconscious and quiet. Should the obstetrician desire active voluntary expulsion of the body, the anesthetist discontinues the cyclopropane, increases the oxygen, and the patient is awake in a few breaths ready to push as instructed.

As soon as the baby is delivered, all cyclopropane is discontinued, oxygen is increased to 4 to 6 liters per minute (exhaling valve open) and continued until the pulsation in the umbilical cord ceases. The baby thus delivered is usually a pink color and cries even before the cord is severed.

For Repair

After the baby and placenta are delivered, the administration of cyclopropane for the repair is the same as for any

other surgical procedure. The following method has proved satisfactory. The bag is filled with air sufficient for tidal exchange. The mask is placed on the patient's face, and a closed system is effected with the soda lime absorber system in the circuit and oxygen added at a rate slightly above the maintenance level (500 to 800 cc per minute). Helium is set at 1000 cc per minute, cyclopropane is gradually increased to the rate of 500 to 700 cc per minute depending on the risk and size of the patient, premedication and so on, and the oxygen is decreased to maintenance (200 to 400 cc per minute).

As soon as the lid reflex is lost (about three minutes) cyclopropane and helium are shut off. After one half to one minute cyclopropane is added slowly to attain the proper depth of anesthesia usually at 200 to 300 cc per minute for the first five to ten minutes and 50 to 100 cc per minute for the next half hour. Helium is either discontinued or added in small quantities throughout (100 to 200 cc per minute).

This method may be used for other surgical obstetrical procedures such as forceps delivery, cesarean section and version.

COMMENTS

In the 1392 cases herein reported cyclopropane would seem to meet adequately the demands placed upon it by all types and extremes of obstetrical conditions. It has been subjected to rigid scrutiny in both the simplest and most grave operative procedures; it has been employed in cardiacs, in renal and other toxemias, in anemias and in the presence of shock and hemorrhage.

No toxic effects to mother or baby have been observed in any instance.

Irritation to the respiratory tract has been minimal. It has been administered in numerous cases of upper respiratory tract infections and in several of bronchitis of moderate degree. Laryngospasm was noted in eighteen cases. Atropine given before delivery has reduced the amount of mucus and laryngospasm is rare since this precaution has been taken.

Analgesia was maintained during the bearing down efforts of the second stage of labor to a degree adequate and satisfactory to the obstetrician, patient and anesthetist without

impairing the effectiveness of uterine contractions. The only failures observed in analgesia occurred in voluntarily uncooperative patients or more frequently in those who were uncooperative as a result of previous sedation.

Adequate relief for *epiotomy* was readily obtained in most instances. In those cases in which pain was exhibited by the patient no unpleasant memory persisted if the anesthesia was deepened to a brief loss of consciousness and such a procedure did not delay delivery.

Anesthesia was employed for *major obstetrical operations* of all degrees with adequate relaxation for performance of these procedures at the same time maintaining the mother in good color free of evidence of anoxia. In no instance did it become necessary to supplement the anesthetic or substitute another anesthetic agent. Low forceps and midforceps operations breech extractions versions craniotomies and cesarean sections were performed with equal gratification from the anesthetic point of view. In several instances contraction rings yielded to cyclopropane. Infants were delivered in good color clinically free of anoxia suffering no embarrassment other than that attributed to trauma of labor or delivery.

One patient admitted with *primary uterine tetany* of marked intensity was given cyclopropane to relax the uterus in an effort to avoid rupture of that organ and to preserve the life of the baby. It was necessary to maintain anesthesia during the entire preparation for surgery as well as for the cesarean section itself since any lightening of anesthesia permitted recurrence of the tetany. This case undoubtedly was the supreme test of the relaxing power of cyclopropane in this series and a live healthy baby and mother and an unruptured uterus acclaimed this crowning success.

Cyclopropane would seem to be the anesthetic of choice in *toxemias of pregnancy* because it neither impairs the liver or kidneys nor embarrasses these organs when already diseased. Forty-four toxemic patients were anesthetized with cyclopropane. All recovered except one patient with convulsive toxemia on a renal basis who was admitted in almost continuous uncontrollable convulsions. The seizures which stopped only after anesthesia recurred a few hours after the

cesarean section and the case terminated fatally twenty four hours following surgery

Eighty six *cesarean sections* were performed under this agent Two patients died following the procedure one a cardiac admitted with grave decompensation associated with pulmonary edema and coma the other the eclamptic mentioned above The anesthetic agent did not seem to be a factor in either fatality Distention of the intestines after cesarean section under cyclopropane anesthesia was noticeably reduced as compared with other anesthetic agents

Fifty nine babies (42 per cent) required resuscitation all had a purely obstetrical cause for their asphyxia such as a difficult or an instrumental delivery prolapsed cord prolonged labor or embarrassed fetal heart tones in labor

Emesis was probably more frequent with cyclopropane than with nitrous oxide or ethylene but clinically observed to be less and of shorter duration than is usually noted with ether Emesis in obstetrics is more frequent than in surgery since the proximity of onset of labor to the taking of food is beyond control Routine treatment with Trendelenburg position and suction alleviates this complication

SUMMARY

- 1 A series of 1392 obstetrical cases is reported in which cyclopropane was the sole anesthetizing agent

- 2 A technic of administering cyclopropane helium and oxygen for the various phases of the obstetrical procedure is propounded

- 3 Cyclopropane is adequate anesthesia for all obstetrical procedures since its flexibility permits analgesia and provides anesthesia capable of any required relaxation

- 4 Cyclopropane is safe to mother and baby

- 5 Anesthesia may be obtained with cyclopropane without apnoea

- 6 Where fetal oxygenation is embarrassed by labor cyclopropane is a distinct asset

- 7 With proper observation of precautions against explosion this hazard should be no greater with cyclopropane than with other anesthetic agents

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THE TECHNIC OF SUPRAVAGINAL HYSTERECTOMY*

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ALTHOUGH present day teachers and authors are strongly advocating total removal of the uterus by the abdominal or vaginal approach much can still be said in favor of supravaginal or supracervical hysterectomy in certain instances. It is not the purpose of this discussion to weigh the merits of the vaginal or abdominal approach nor is it my desire to advocate the subtotal in favor of the total operation. It is my opinion and the belief of many trained gynecologists that each of these methods has its definite indications. To attempt to use one procedure in all instances would be an error of judgment resulting in an increased morbidity and mortality.

A few brief paragraphs about preparation of the patient and choice of incision may not be amiss at this time.

On entrance to the hospital or before if possible every patient submitting to a surgical procedure should have a complete *physical examination*. This should include a blood count, urinalysis and if indicated an electrocardiogram and other laboratory studies. Too often a patient has a stormy convalescence because of a cardio renal vascular or pulmonary condition which was not recognized until the added strain caused by an anesthetic or operative procedure increased the symptoms or caused complications which if recognized and guarded against would have made the procedure a less hazardous one.

The matter of *preoperative sedation* and choice of *anesthetic agent and method* should be left to the physician anesthesiologist or if one is not available to the attending surgeon.

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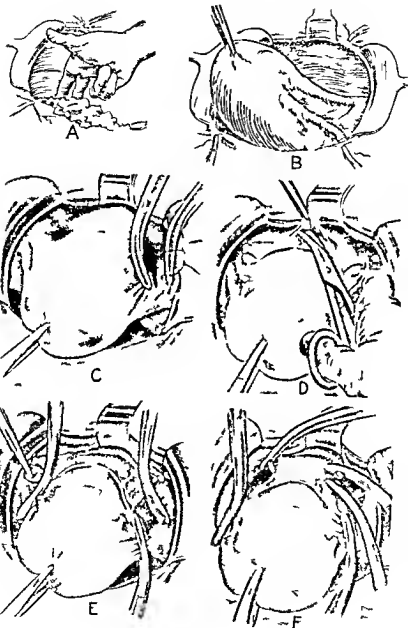


Fig 4—(See text)

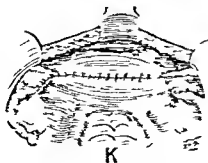
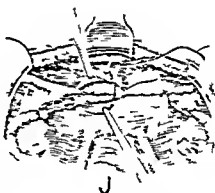
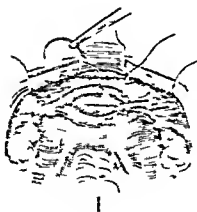
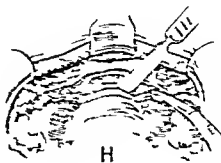
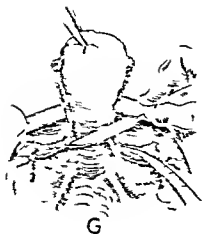


FIG 4—(Continued)

after discussion with the nurse anesthetist. The choice of a suitable anesthetic for the particular case does much toward simplifying the operation and avoiding disagreeable sequelae.

That the *Trendelenburg position* carries certain dangers because of difficulties in aerating the lung bases must be admitted. The advantages it gives the operator, however, outweigh the objections to it, and if at the end of the operation and on the first postoperative day oxygen is administered to the patient by one of the accepted procedures now in use complications need not be feared.

Although the midline suprapubic *incision* enjoys the greatest usage, some operators prefer the Pfannenstiel incision. The important point in the selection of the incision is that it will give adequate exposure for what must be done. To make the procedure more difficult merely for cosmetic reasons is poor surgical judgment.

When the abdomen of a patient in the Trendelenburg position is opened and a Balfour retractor put in place, the bowel is usually found in the upper abdomen, and very little trauma is caused by walling off the upper abdominal cavity by means of moist lap pads or a rubber dam (Fig. 4 A). If exploration of the upper abdomen is to be done, it should be carried out before the pads are placed. After the pelvic operation has been completed, it is poor policy to invade the upper abdomen.

At this point all adhesions which are present should be separated and bleeding carefully controlled. The adnexa are then carefully inspected, and a decision arrived at as to whether they are to be left behind or removed. Normal adnexa should never be removed as they have a definite function for years after the menopause. To remove the adnexa definitely increases the morbidity rate of hysterectomy.

The uterus is now grasped with a tenaculum forceps as shown in Figure 4 B, and by drawing it upward and toward the promontory of the sacrum, the round ligaments are put on stretch and brought into view. With a small clamp the right ligament is clamped doubly, 2 cm. away from its insertion into the uterus (Fig. 4 C). With a scissors the ligament is cut between the clamps, and the broad ligament thus

opened. The left round ligament is then treated in a similar manner.

The operator now inserts the tip of the closed scissors under the right side of the broad ligament where it was opened and carefully burrows across to the opening made on the left side. This separates the reflection of broad ligament from the uterus thus making it possible to cut across the path prepared and thus make the bladder flap. The bladder can now be pushed downward well below the level of amputation bringing into view the uterine arteries and veins (Fig 4 D).

The operator now punctures the posterior layer of broad ligament with a straight scissors as shown in Figure 4 E. A clamp is then applied with one blade through this perforation and the other outside the infundibulopelvic ligament. This grasps the ovarian artery and vein, suspensory ligament of the ovary and the fallopian tube at its insertion into the uterus. A second clamp is applied and the structure cut between the clamps (Right side of Fig 4, E). The ovary and tube have now been freed from the uterus and their blood supply preserved. A chromic catgut No. 1 ligature is now applied, the clamp removed and the adnexa dropped into the pelvis out of the operator's way. After both sides have been similarly treated the posterior layer of the broad ligament is cut down along the uterus until both uterine arteries and veins have been exposed as shown in Figure 4 F. The vessels are doubly clamped and cut. A chromic No. 1 catgut stitch is now fixed into the cervix and the vessels are tied against the stump. The clamps attached to the uterus may now be removed as the blood supply has been stopped.

Figure 4 G, shows the uterus at this stage with the posterior wedge being cut into the cervix at the level of the internal os. The anterior wedge is then prepared as in Figure 4 H thus completing the removal of the uterus. A stitch with No. 1 catgut on a cervix needle is now taken through the anterior lip of the cervix through the round ligament and out through the posterior lip of the cervix. When this stitch is tied as in Figure 4 I the round ligament is pulled into the

stump thereby assuring adequate support after both round ligaments are thus buried. The remainder of the cervix is closed with a running stitch. Peritonealization is then carried out by using No. 0 chromic catgut on a fine round needle. The stitch is begun at the right infundibulopelvic ligament. A bite through the anterior and posterior leaf of the broad ligament is taken and the tied end of the infundibulopelvic ligament is buried (Fig. 4 J). The two layers are entirely closed with the same stitch until the left adnexa is reached when again the tied end of the adnexae is buried thus completing the operation.

All clots are removed. A final inspection for bleeding or raw surfaces is made and the lap pads removed. The omentum is then brought down into the pelvis and a layer by layer closure of the abdominal wall is carried out. The peritoneum is closed with plain No. 0 catgut using a purse string stitch in the lower one third of the incision to reestablish an anterior vesicle space. At this stage the table is straightened and a high concentration of oxygen is administered to the patient. The muscle and fasciae are approximated with three interrupted figure of 8 catgut stitches. These do away with the need for retention sutures. The fasciae are then approximated with a chromic No. 1 running catgut stitch. The skin closure is interrupted using the dermal stitch.

Postoperatively the patient is limited to sips of warm water after the period of nausea until the third day. Deep breathing and exercises to prevent thrombosis are compulsory. The daily caloric and fluid requirement is given by venoclysis. With this procedure nausea and distention are prevented. After an enema the morning of the third day a soft diet is permitted and rapidly increased to a general tray. The patient is out of bed on the seventh day and home soon thereafter.

SOME PHASES OF THE IMMEDIATE CARE OF THE NEWBORN

WILLIAM B. SERBIN, M.D.

PARTURITION, although biologically a normal process, is fraught with potential danger to the child. While its course through the birth canal is passive, factors such as premature onset of labor, prolonged pregnancy, difficult labor, type of delivery, and the sudden changes in metabolism that are incident to birth constitute hazards which call for immediate remedial measures. Our concern for the child need not imply that we are unmindful of the maternal aspects of pregnancy and labor; the improved maternal mortality statistics of the last decade attest to the contrary. But we have not attained to the level of an irreducible minimum in either maternal or child mortality. Prophylactic measures directed to these ends, although they demand meticulous attention to detail as well as the acquisition of new techniques, can further contribute to a lower fetal mortality and morbidity.

In our discussion of the newborn child let us review the conduct of a given case of labor with special reference to analgesia and anesthesia and their effects, the newer methods of resuscitation, and the prevention of hemorrhage and anemia. Routine procedures such as type of examination, preparation of the patient for delivery, care of the cord stump, and treatment of the eyes are well standardized and need not be considered here.

Care of the newborn infant begins long before delivery. The improved methods of prenatal care in early pregnancy, the dietary regulations and the maintenance of normal health are also methods aimed at the development of a normal fetus in utero. In brief, the physician does all he can to cope with situations which may be under his control. Factors such as

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anatomic malformations excessive weight of the fetus within certain limits and premature onset of labor are beyond the control of the physician. The conduct of labor is modified and sometimes even rendered dangerous in some respects by the demands of patients for painless labor and operative interference.

Analgesia and Anesthesia

Relief from pain is an inherent desire of all patients and it is a just one. In addition to the older drugs such as morphine and scopolamine we now have a wide variety of newer agents which have a proved value as analgesics or hypnotics. These are not entirely without danger however and there are many limitations to their indiscriminate use. Morphine a narcotic used alone or in combination with scopolamine or magnesium sulfate has long had its advocates. It is an excellent agent when properly used. The anesthetic gases nitrous oxide ethylene and the more recent cyclopropane when used intermittently as analgesics also serve very well. The newer sedatives the barbiturate derivatives such as pentobarbital amytal sodium amytal allunal dial secunal are also satisfactory and more recently paraldehyde another type of hypnotic has been employed. These agents are employed singly or in combination according to the desires and experience of the individual physician. This is a brief list although sufficient for our purpose the number and variety are increasing and yet the ideal analgesic to date has not been found. An ideal analgesic may be defined as one that in all cases will bring about complete relief from pain total amnesia with no toxic side reactions to the mother and no ill effects to the fetus in utero.

Some obstetricians have their personal preferences using one routine method for all patients others attempt to suit the agent and the dosage to the patient's needs—a more logical and satisfactory method. Still others prefer no analgesia at all. I believe the mistakes made with reference to analgesic agents are the use of a single drug in all cases without discrimination as to the time of administration (they are frequently given too early before they are needed for relief of pain) excessive dosage without reference to prematurity or

fetal tolerance the production of total amnesia with its excitement and prolonged narcosis which in turn deprives the patient of her own powers of cooperation and increases the operative incidence. I wish to emphasize these aspects of analgesia not because I am opposed to the use of these agents—I employ them also and have my preferences—but because in their use we must exercise judgment in their selection always bearing in mind their effect on the fetus in utero. The same applies to prolonged anesthesia the effects of which will be referred to later in the discussion of Asphyxia Neonatorum.

Establishment of Respiration in the Normal Child

The normal baby following an uneventful labor with no anesthesia or with only brief obstetrical anesthesia is born quite pink, has good muscle tone and attempts to cry immediately. Even under the most favorable circumstances the baby usually has mucus and liquor amnii in its mouth and throat and occasionally meconium and other debris. The baby rids itself of these substances by crying or sneezing before it attempts to breathe. It may also make attempts at swallowing and in so doing may aspirate mucus and other debris.

To prevent aspiration of mucus a soft collapsed rubber ear syringe should be inserted into the mouth and throat and the contents aspirated. This operation may be repeated several times taking care to introduce the syringe in the collapsed state and aspirating within the mouth before withdrawal. A soft rubber catheter with a glass saliva trap which can be inserted into the doctor's mouth may likewise be used for this purpose.

If mucus or fluid obstructs the trachea and bronchi a hard rubber catheter (F 16) is inserted into the trachea by depressing the tongue and lifting the epiglottis. The catheter is inserted to the bifurcation of the trachea and the contents are aspirated thus insuring complete clearance of the air passages. The catheter should then be removed and cleansed and may be reinserted so that the baby can breathe through it if necessary. It is interesting to note that after the air passages

are cleared respiratory movements of the chest begin and in the flaccid baby muscle tonus makes its appearance and respiration is quickly established

Cutting the Cord

While this preliminary treatment for the establishment of early respiration is being carried out the cord has not yet been clamped and cut. It continues to pulsate and the placenta continues to discharge its blood into the fetus. The cord should not be clamped and cut immediately following delivery except under unusual circumstances for the fetus is entitled to all of the placental blood. Cutting the cord immediately deprives the fetus of 100 cc. or more of blood and it has been suggested that this loss to the fetus is tantamount to a hemorrhage (Fig. 5). Leaving the cord uncut until the infant has received the placental blood is of critical importance in the case of premature infants and in full term infants it is a prophylactic measure in the prevention of anemia. It has been shown that anemic infants at birth require about eight months to a year to restore their normal blood levels.

Conservation of Body Heat

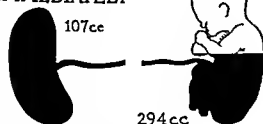
After the cord has been cut the baby is transferred to a heated baby receiver. Maintenance of body heat is important in the normal newborn infant and even more important following difficult labor and in the premature infant. For this purpose the electrically heated baby receiver is ideal although not absolutely essential. This type of baby receiver requires approximately twenty minutes to become heated. A Nobel box with a 75 watt lamp is also satisfactory and works very well even with premature infants.

Asphyxia

The term asphyxia as applied to the newborn is a misnomer since it has reference to death by choking as it occurs in drowning. Apnea the inability or failure to breathe and anoxia the lack of oxygen are the more nearly accurate terms. The term asphyxia has been used for so long however that I shall employ it here. The old division of asphyxia

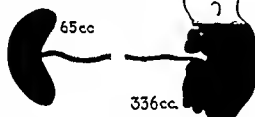
THE RELATION BETWEEN the AMOUNT of BLOOD in the PLACENTA and in the INFANT

CORD CLAMPED
IMMEDIATELY



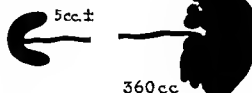
INFANT
DEPRIVED
of
PLACENTAL
BLOOD

CORD CLAMPED
PULSATIONS CEASE



INFANT
RECEIVES
LESS THAN $\frac{1}{2}$
of
PLACENTAL
BLOOD

CORD CLAMPED at
SEPARATION
PLACENTA



INFANT
RECEIVES
PRACTICALLY
ALL of
PLACENTAL
BLOOD

Fig 5—Diagram to show relative losses of blood to the fetus at birth with immediate clamping and delayed clamping of the cord. The figures given are approximate; they indicate that if the cord is clamped immediately 107 cc of blood can be obtained from the placenta; if the cord is clamped after pulsation ceases about 65 cc can be recovered from the placenta; after placental separation a small amount of blood can be recovered. The true figure for the total volume of blood in the fetus, placenta, and cord is about 475 cc. The diagram however indicates sufficiently well what happens when the cord is clamped under these different sets of circumstances. (After W F Windle, H L Alt and G B Marsh.)

into *asphyxia livida* and *asphyxia pallida* has served as a brief classification for a long time but is now inadequate. According to Vandell Henderson there are four types of asphyxia neonatorum all due to or associated with deficiency of oxygen.

1 *The livid baby* In this type of asphyxia the baby is blue the circulation of blood between the child and the placenta having been impeded. The capillaries in the skin are engorged. The infant usually is not deeply narcotized unless large doses of morphine or the barbiturates have been given during the first stage of labor. Muscle tone is generally good.

2 *Asphyxia pallida* This is a serious type of asphyxia. The skin is pallid or marble white the capillaries are empty and there is a lack of muscle tonus the cerebral centers are paralyzed although the vasomotor system is not involved.

3 *Intracranial hemorrhage* This type of asphyxia develops after birth and is associated with very rapid or difficult operative delivery. The child may breathe at first but as the hemorrhage continues the medullary centers become more depressed resulting in deprivation of oxygen. The sensitivity of the respiratory center to carbon dioxide is diminished and apnea occurs.

4 *Obstructed fetal circulation* Obstruction of the fetal circulation during delivery may result in premature attempts at respiration with meconium and debris being drawn into the tracheobronchial tree.

The commonest cause of asphyxia neonatorum is the excessive or untimely use of narcotics and hypnotics during labor. These agents are respiratory depressants and when administered to the mother they diffuse through the placenta and enter the fetal circulation. Barbiturates have a more prolonged depressing action on the fetal respiratory center than does morphine in equivalent dosages therefore the carbon dioxide response to the baby is more favorable after morphine analgesia than after barbiturate analgesia.

General Principles in Resuscitation of the Newborn—The lungs after delivery and after respiration has become established expand very gradually they are still in a state of atelectasis. Inasmuch as they become inflated slowly it is impor

tant in any method of resuscitation not to deflate them for this will produce more atelectasis. Upon the establishment of respiration by artificial means there is an improvement in muscle tonus and this aids voluntary respiration on the part of the fetus. By preventing motion in premature infants we may also prevent the occurrence of pneumonia a frequent and fatal outcome.

We no longer resort to vigorous methods of resuscitation cold water shaling the Sylvester method spanking and heavy pressure are not used. They aggravate damage where it is already present and may produce damage where it is not yet present.

In attempting to establish respiration respiratory movements should be carried out about fifteen times per minute. This may be done with good results by aiding the baby's breathing and rebreathing with intermittent gas flow. If continuous gas flow is used this should be given at the rate of 6 liters per minute.

After mucus and debris have been cleared from the trachea and other air passages a continuous flow of oxygen 95 per cent and carbon dioxide 5 per cent may be administered by catheter from an infant resuscitator (Figs 6-7). Where such an apparatus is not available the use of the tracheal catheter with mouth insufflation at the rate of fifteen times per minute is very satisfactory. It should be borne in mind that strong pressure must never be employed and that methods of resuscitation should not be discontinued too early. Body heat must be conserved while these procedures are carried out.

Immediate Care of the Skin

Many methods of skin care have been tried. Our main purpose whatever the method is to prevent skin infections more especially impetigo and pemphigus neonatorum. In some maternity hospitals the vernix is not removed. This practice is open to question inasmuch as it is not a clean method. On the other hand it has frequently resulted in a marked diminution of pustules in the skin. In still other hospitals olive oil is employed to remove the vernix and the skin is treated thereafter

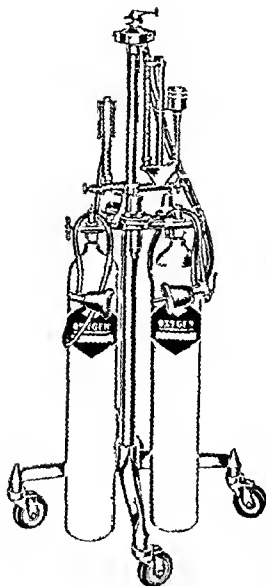


Fig. 6—Helium-oxygen breathing apparatus, portable model (Courtesy of the Ohio Chemical & Manufacturing Company)

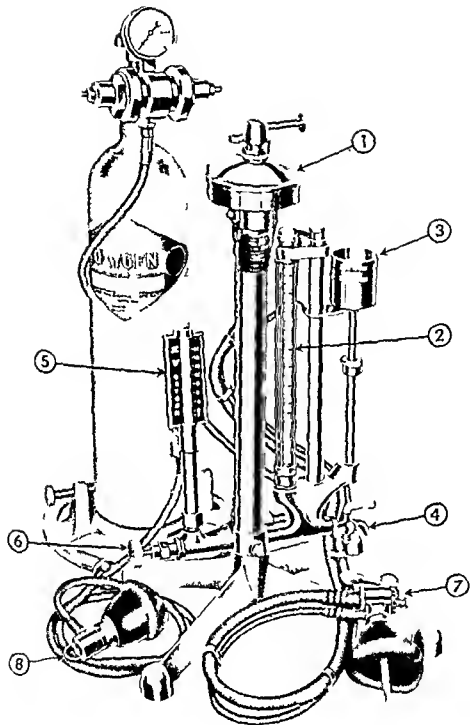


Fig 7—Heidbrink infant resuscitator (1) Automat which regulates the amount of positive pressure exerted at the inhaler (2) Water manometer gauge calibrated from 0 to 16 mm Hg which registers the pressure being exerted in the lungs (3) Escape valve adjustable up and down to limit any pressure as set on the manometer between $6\frac{1}{2}$ and 16 mm Hg (4) Drain cock (5) Flowmeter (6) Flowmeter control valve (7) Resuscitation inhaler and tubing (8) Continuous flow inhaler and tubing (Courtesy of the Ohio Chemical & Manufacturing Company)

with water only and no soap. This method is also satisfactory. In our nursery aquaphore merthiolate cream* is employed to remove the vernix from all newborn infants except those born prematurely. In the case of the latter there is no occasion for haste the vernix may be removed after several days by this method if the baby is progressing satisfactorily. This treatment is carried out without removing the infant from the crib or incubator.

If pemphigus or pemphigoid lesions appear they are opened with sterile alcohol (65 per cent) applicator and treated with 2 per cent ammoniated mercury ointment. Sulfathiazole cream 5 per cent has also been employed but not with great success although these lesions are presumably infected with *Staphylococcus albus*. Strict isolation and surgical asepsis should be enforced.

Use of Vitamin K

Vitamin K is of value in hemorrhagic disease of the newborn associated with hypoprothrombinemia. It is of little or no value in traumatic hemorrhage. It may be used prophylactically in cases of premature and prolonged labor. 2 mg. be given administered to the mother twice daily. It may also be employed following delivery and may be given to the baby in doses of 1 mg. (Thyloquinone) per cubic centimeter in milk or water once daily or in doses of 1 mg. hypodermically (Synkamin). Its use is important in premature infants because in them there is a tendency toward hemorrhage on account of fragility of the blood vessels. Vitamin K has its greatest field of usefulness however in cases of hemorrhagic diathesis where it may be given hypodermically or by mouth 1 mg. once daily for the first five days.

SUMMARY

The conduct of labor with special reference to the use of analgesics and prevention and treatment of asphyxia neonatorum has been briefly reviewed. Emphasis has also been

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placed upon prophylaxis with reference to blood loss and prevention of anemia hemorrhage and infection of the skin in the newborn

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CLINICAL USE OF VITAMIN K IN OBSTETRICS*

AUGUSTA WEBSTER M D †

and

J E FITZGERALD M D ‡

In two previous articles¹ we have reported some observations on the use of vitamin K in women in labor and in the newborn. Since then other investigators² have reported results quite at variance with ours. We therefore report some additional observations with a summary of the entire series treated.

During a period of eighteen months approximately 5370 women were delivered in Ward 51 at Cook County Hospital. This ward is devoted exclusively to the care of parturients who have no abnormal obstetrical condition, are free of infection and whose babies are over thirty weeks gestation. Of this number 1720 received vitamin K during labor. Prothrombin determinations were done on the mother before administration of vitamin K at the time of the delivery and on the infant's cord blood at birth. These determinations were done by a modification of the Smith⁴ method previously reported.² Other determinations were made on the babies for several days after birth by the micro method of Kato and Poncher.⁵ The following results are from cases not previously reported. The medication used on these patients was 2 methyl-1-4 naphthohydroquinone diphosphoric acid ester tetrasodium salt (Synkayvite Roche) in 10 mg doses.

From the Department of Obstetrics, Cook County Hospital and the Department of Obstetrics and Gynecology, Northwestern University Medical School. Aided by a grant for technical assistance arranged by Dr. Herman N. Bundesen, Commissioner of Health, Chicago. The vitamin K used in this study was furnished by Hoffman-La Roche, Inc.

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CASE IV—On the third day numerous petechiae appeared on the face neck and scalp Subconjunctival hemorrhages were found in the right eye The prothrombin level was 37 per cent Vitamin K was given and on the next three days the level was 77 83 and 92 per cent respectively

CASE V—This infant vomited bright red blood on the third day The prothrombin level was 30 per cent After vitamin K was given the level rose to 93 per cent and was 100 and 103 per cent on the next two days

CASE VI—Hematuria appeared on the third day The prothrombin level was 26 per cent One hour after vitamin K was given the level rose to 56 per cent The next day it was 62 per cent and 80 per cent on the following day

CASE VII—Epistaxis occurred on the third day and ecchymoses about the left eye The prothrombin level was 18 per cent vitamin K was given and on the following day the level was 78 per cent

CASE VIII—On the third day bleeding occurred from excoriations on the chin and the prothrombin level was 14 per cent One hour after the administration of vitamin K the level was 24 per cent and on the following day 80 per cent

COMMENT

There seems to be considerable misunderstanding about the value of the vitamin K products in obstetrics Part of this is due to the variety of tests used to determine prothrombin content All of our tests have been done by two certified technicians who have devoted their entire time to determinations done on these patients Standards were checked daily so that we have a right to consider the results accurate Another misunderstanding concerns the value of vitamin K in the prevention or treatment of hemorrhage of the newborn due to birth trauma So far as we know vitamin K will be valueless in prevention or treatment of hemorrhage of this type

Nevertheless there seems to be a wealth of evidence to show the value of the medication in obstetric cases The following facts may be cited

1 Administration of vitamin K to mothers in labor produces a higher prothrombin content in both mother and baby

2 Such medication prevents the definite prothrombin decrease found when the mothers have received certain barbiturates as analgesics

3 Babies admittedly show a decrease in prothrombin content from the second to the fifth day of life. This decrease is not present if the mother receives adequate vitamin K medication during labor or if the baby receives vitamin K after birth

It seems significant that hemorrhage of the newborn occurs normally during the period of lowered prothrombin content. The fact that babies in this series who had bleeding invariably showed a markedly low prothrombin content should be of importance although low prothrombin content may also be found frequently when there is no gross evidence of hemorrhage

We believe it is not an accident that 42 out of 44 neonatal hemorrhages occurred in patients who had no vitamin K. Furthermore it seems reasonable that numbers of undiscovered but perhaps not unimportant hemorrhages of the newborn could be prevented by the use of vitamin K.

It seems reasonable to assume therefore that vitamin K has a definite place in the prevention of neonatal hemorrhage but it must be emphasized that hemorrhage of traumatic origin will not be affected by such medication

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MANAGEMENT OF OBSTETRICAL HEMORRHAGES*

FREDERICK H FALLS MD FACST

OBSTETRICAL hemorrhages are among the most serious complications of pregnancy. Their gravity depends largely on the fact that they are seldom anticipated and that the accoucheur in most cases has no clear plan of action for prevention or control. Too dogmatic assertions must not be made about the proper handling of a given case since the facilities for management vary widely in different cases. The same may be said for the training and experience of the obstetrician handling the case. Since this is so I shall discuss particularly the practices which obtain in my clinic and try to set forth the principles upon which such practice has been founded. Consideration will also be given to the more common obstetrical hemorrhages from placenta previa, premature placental detachment and rupture of the uterus as well as to post partum hemorrhage.

POSTPARTUM HEMORRHAGE

Postpartum hemorrhage while it is the most common form of obstetrical hemorrhage is usually avoidable in properly conducted labors. Many etiologic factors may contribute to this complication and the successful management depends on a thorough understanding of the pathology and application of the appropriate treatment.

ETIOLOGY—*Uterine atony* is the most common cause of postpartum hemorrhage (see Fig. 10) and may be due to several factors among which may be mentioned exhaustion of the uterine musculature from long hard labor, degenerative changes in the myometrium (fibrosis uteri), shock in

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the mother uteroplacental apoplexy secondary to ablatio placentae placenta praevia arcuate bicornuate uterus overdistention from hydramnion or multiple pregnancy and a fibroid uterus

SYMPTOMS—Whatever the cause the symptoms are very similar. There is a continuous flow of dark venous blood coupled with a tendency for the uterus to balloon up and

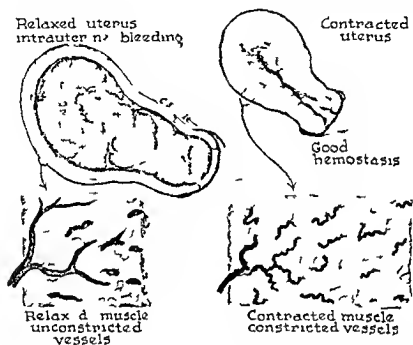


Fig. 10.—Gross and microscopic (differential) appearance of uterine wall after labor illustrating the principles of hemostatic support mechanism depending on

to feel soft and boggy and Crede expression of the uterus yields large clots. In normal cases the upper margin of the fundus should be about three fingerbreadths below the umbilicus immediately after the expulsion of the placenta. In atonic cases it will be found at or above the umbilicus. The pulse increases in rate and becomes soft and compressible. Pallor, sighing respirations, air hunger, syncope, all may appear in rapid succession.

Treatment

Prophylactic injection of an impulse of pituitrin immediately after the birth of the baby followed by a tablet of ergotrate, $\frac{1}{3}$ of a grain by mouth, or an active hypodermic preparation of ergot after the birth of the placenta is valuable. Gentle massage in addition should cause firm uterine contraction. If it still tends to relax, more vigorous massage is used and all clots expressed from the uterine and vaginal canals. These clots are saved and measured as is all blood lost from the time the diagnosis of postpartum hemorrhage is made. Some of the blood should be sent to the laboratory for matching to expedite transfusion should transfusion prove to be necessary later in the course of the treatment.

If the uterine atony is not overcome as shown by failure of sustained contraction and retraction, *packing of the uterus* should be immediately resorted to. The packing of a uterus may be defined as a simple obstetrical procedure, but it is usually thoroughly misunderstood by the average obstetrician. The first step is to reprepare the vulva and vagina by sponging with lysol. The doctor changes gown and gloves. The pack to be used is soaked in weak 1 per cent lysol solution then wrung out. It is contained in a sterile wide mouthed jar and held to the left of the operator. The left hand is introduced into the birth canal up to the fundus of the uterus. The clots or pieces of placenta or membrane are rapidly loosened from the uterine wall and brought out of the vagina. The left hand is again introduced into the vestibule whereupon the operator with his right hand seizes the end of the gauze strip with a dressing forceps and packs the palm of the left hand with gauze. This is then carried up to the fundus of the uterus and carefully packed in the right hand making simultaneous counterpressure on the fundus through the abdominal wall. Having packed in one handful of gauze the procedure is repeated until no more gauze can be put into the uterus. The vagina is also packed tightly in severe cases. During this procedure hypodermoclysis of normal salt solution 1000 cc. can be started and digalin grain $\frac{1}{30}$ and caffeine sodium benzoate grains 5 are administered hypodermically. In severe cases the salt solution and matched blood or plasma

may be given intravenously. In women with small veins or fat arms or when there is considerable shock it may be necessary to cut down on a cubital vein in order to introduce a needle or cannula. The head of the bed should be lowered and the limbs tightly bandaged from the toes to the thighs. In extreme cases it may be necessary to compress the aorta through the abdominal wall. Inhalations of oxygen are of distinct value where air hunger is manifest; the gas is best given through a nasal catheter or oxygen tent. The patient's body should be kept warm throughout the treatment and all causes of shock eliminated insofar as possible. The hot intrauterine douche is warmly recommended by some authors but is not used in our clinic since we feel that its action is neither as sure nor as prolonged as is the pack.

Tears of the cervix are pulled down by placing ring forceps on the anterior and posterior cervical lips while a deep vaginal hand retractor exposes the fornices. The repair is made by interrupted sutures of chromic No. 2 catgut which extend from the serosa to the mucosa of the cervix and from the apex of the tear to the free margin of the cervix. About three interrupted sutures are taken.

Postpartum hemorrhage secondary to a *ruptured varicose vein of the vagina* usually gives rise to a steady flow of venous blood which is not influenced by the contracted state of the uterus. For these cases we use a tail sponge which is like a laparotomy sponge except that it is longer and narrower. This can be wrung out of 1 per cent lysol and the uterus and the upper vagina tamponed off while the search for the bleeding point is being made using the wide deep retractors for exposure. A single catgut suture around the bleeding point is all that is required as a rule.

Patients with a history of previous postpartum hemorrhage should be delivered in a hospital if possible with everything prepared to combat this complication if it recurs.

Postpartum hemorrhage associated with *rupture of the uterus* (Fig. 11) may be very misleading because the major part of the hemorrhage may occur into the abdominal cavity and only a small amount of blood appear at the vulva. The patient is frequently thought to be in shock for this reason.

and is often treated for this complication. In a given case when from the history rupture appears to be a possibility the patient should be placed in the lithotomy position. The operator should change gown and gloves and insert the left hand

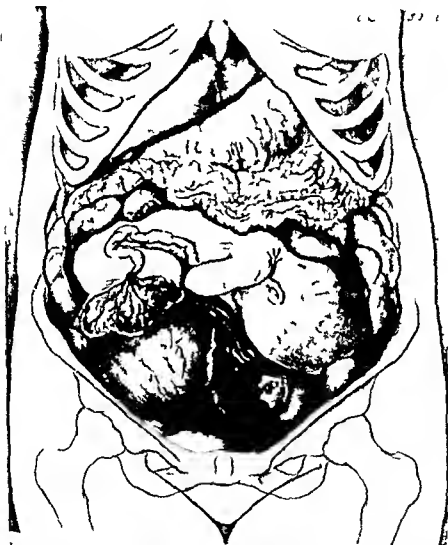


FIG. 11.—Complete rupture of uterus. Tear in lower uterine segment results in intra abdominal concealed hemorrhage or apparent vaginal bleeding. Infection and shock add to the gravity of the situation.

into the vagina. The tear if present will be found in the lower uterine segment off to one side and usually the cervix is involved in the tear. Occasionally there is a *colporrhoeis* in which the posterior wall of the vagina is torn away from the

cervix. The tear is as a rule easily felt and is diagnosed by the fingers extending out into the parametrium or into the abdominal cavity.

In such cases the uterus and vagina should be tightly packed immediately and the patient transfused and laparotomy performed as quickly as possible. Hysterectomy is practically always indicated and drainage of the pelvis advisable. The speed with which these steps can be properly executed is the measure of the efficiency of the obstetrical service.

A woman with a history of *repeated se cre postpartum hemorrhages* should be considered a candidate for an interposition operation which carries with it sterilization. Since the operation is done vaginally and the cystocele which is usually present is repaired in this way, a trachelorrhaphy if necessary and a perineorrhaphy will complete the repair work.

Postpartum hemorrhage with *retained placenta* is relatively common. The placenta may be retained in whole or in part. The retained portion results in the failure of proper contraction and retraction of the uterine wall at the placental site. Under these circumstances it is necessary to remove the placental tissue manually after the failure of pituitrin and Crede expression. Following the removal if the blood loss has been severe the uterus should be packed prophylactically and ergotrate given. Occasionally a postpartum hemorrhage due to retained pieces of placenta occurs several days after the patient is up and about. In these cases it is usually advisable to return the patient to the hospital and remove the pieces with a blunt curette.

The *amount of blood lost* in a given case is only a rough index of the seriousness of the hemorrhage. The reasons are that patients vary greatly in their ability to stand shock and hemorrhage and the total amount of blood in the vessels of different patients at the time of delivery varies greatly.

It is well known clinically that a patient who has had an antepartum hemorrhage or who is anemic from some other cause such as *pyelitis of pregnancy* does not endure well even a small postpartum hemorrhage. For this reason in such cases especially *every drop of blood should be conserved*.

There comes a time during a postpartum hemorrhage when the patient's blood loses its ability to clot spontaneously. This would seem to be due to dilution of the thrombogenic elements of the blood. Tight packing of the uterus and blood transfusion are the only efficient remedies for this condition. The fact that this condition occurs late in the course of a postpartum hemorrhage emphasized the necessity for prompt active and vigorous treatment of all cases as soon as the diagnosis is made. The best defense in postpartum hemorrhage is a *vigorous offensive management*. Every maternity hospital and community should have available professional donors grouped and ready to respond when called. A specially trained transfusion team should also be available where possible. These details can be provided in almost any community or hospital, if someone sets himself to the task of providing them. I know of no instance where they have provided themselves spontaneously. The more simple the apparatus used the more efficient it is likely to be.

PLACENTA PRAEVIA

ETIOLOGY—Not much is known about the etiology of placenta praevia except that multiparity, twins and fetal anomalies seem to predispose to it.

PATHOLOGY—We speak of two types of placenta praevia. One that is growing in some part at least over the internal os is called *placenta praevia centralis* (Fig. 12) and one that is growing in the lower uterine segment but has not developed over the os is called *placenta praevia lateralis*. The presence of the placenta causes a great increase in vascularity in the uterine wall in the region of its attachment. Here the musculature is edematous and has relatively poor contractility, while its friability is greatly increased. This greatly increases the danger of tears during delivery and gives rise to atonic postpartum hemorrhage as well as to primary bleeding from tears. Severe secondary anemia from antepartum bleeding may be present at the time of delivery and thus increase the danger from even moderate postpartum hemorrhage.

SYMPTOMS—Symptoms of placenta praevia are usually conspicuous by their absence until a hemorrhage slight or pro-

fuse indicates its possible presence. The bleeding is usually painless and causeless and varies from a few cubic centimeters to a fatal hemorrhage. Close observation however may reveal signs and symptoms which should put us on guard. A failure of the presenting part to fit down easily over the



Fig. 1.—Placenta praevia central, often cause severe hemorrhage about the time of fetal delivery. Delivery from below is dangerous to mother and fatal to fetus in most cases.

pelvic inlet is significant. The fetal heart tones at term may be heard noticeably higher in the abdomen than normal. One can usually estimate accurately by rectal examination whether or not the placenta covers the uterine os. This must be done carefully to avoid the possibility of precipitating fresh hemorrhage. There is less danger of contamination of the vagina

by using rectal examinations but the findings in a given case may be more obscure and hence should not be relied upon when indefinite. When the factors strongly suggest placenta prævia vaginal examination may well be done after careful sterilization of the vulva, as if for operation. Gentleness is imperative to avoid precipitating further separation and serious hemorrhage.

The earlier in pregnancy a placenta prævia starts to bleed the more probable it is that a central type exists and the more profuse and dangerous the hemorrhage is apt to be.

DIAGNOSIS—The diagnosis is usually simple, based on the symptoms and signs as described. The condition must be differentiated from causes of painless bleeding in the later months of pregnancy. Cervical polyps occasionally cause such bleeding, but can be readily differentiated by palpation and speculum examination. Partial premature detachment of the normally implanted placenta with apparent hemorrhage may have very little pain and may closely simulate placenta prævia. The failure to feel placental tissue over the internal os and the changes in the fetal heart rate are significant of, although not pathognomonic for premature detachment.

Carcinoma of the cervix while a rare complication of pregnancy does occur, and is usually easily diagnosed by the appearance of the growth, positive Schiller reaction and biopsy.

Treatment

The treatment depends on the facilities available, the skill of the attendant and the stage of pregnancy. No time should be lost in getting the patient into the best surroundings available. All patients should when possible have the advice of a skilled obstetrician. In this day of telephone and telegraph, automobile and airplane there are few valid excuses for an attempt by an untrained doctor to manage a serious type of placenta prævia on his own resources. Nor do we agree to the proposal of calling in the nearest surgeon who although he may be eminently qualified to do a cesarean section is certainly not qualified in the majority of cases to determine accurately whether or not such operation should be done.

A patient with placenta praevia should be removed to a hospital at once if possible. Upon her arrival at the hospital a red blood count, hemoglobin estimation and typing should be done and compatible donors secured. Blood pressure readings should be made every half hour if the loss of blood has been sudden and severe. The patient should be taken directly to the preparation room and prepared for sterile vaginal examination and laparotomy. A careful rectal examination is first done to determine if possible whether a central type of placenta praevia is present. If it is immediate preparations are made for laparotomy unless there is serious contraindication.

If a severe grade of secondary anemia is found with the hemoglobin under 65 or red cells under 3 000 000 a blood transfusion is given as soon as a proper donor can be secured. Five hundred to 1000 cc. may be given by the direct or indirect method. If the anemia is not extreme ethylene anesthesia is employed. If the patient is very anemic local anesthesia is preferred reinforced if necessary by light ethylene or ether inhalations. The low cervical or the classical operation may be done as the operator prefers. There is no additional danger in the former operation as might be expected as a result of the location of the placenta in the lower uterine segment. Pituitrin and ergot are given routinely after the delivery of the baby and placenta respectively. Though rarely necessary the uterus is packed if bleeding is profuse after the birth of the baby and placenta. One end of a 10 yard iodoform gauze strip is pushed through the cervix into the vagina. The rest of the gauze is packed into the uterus and lower uterine segment and the incision is closed. The pack is removed in forty eight hours through the vagina. One thousand cubic centimeters of 5 per cent glucose by hypodermoclysis and 1000 cc. of tap water per rectum are given routinely. The glucose may be given intravenously in case the shock or anemia is severe.

There is an increased danger of puerperal sepsis in these cases due to operative intervention, the depressing effect of the anemia and the possible involvement of the placental site because of its low position. Because of this all unnecessary

vaginal examinations and manipulations are avoided. These patients stand infection poorly.

In all cases where feasible, an x ray picture should be taken before delivery for the detection of fetal deformities if present since this may have an important bearing on the decision as to the time and method of delivery.

If the placenta is not over the lower uterine segment and the fetus not too premature the membranes should be ruptured after which the presenting part usually comes down and tampons the placenta against the lower uterine segment in such a way that bleeding ceases at least until the fetus has been delivered.

Following delivery if there is no bleeding the third stage is treated very conservatively to allow time for contraction and retraction of the placental site and thus minimize the danger of postpartum hemorrhage.

If bleeding begins as soon as the baby is delivered one has no choice but to change gown and gloves, remove the placenta manually and pack the lower uterine segment and vagina as tightly as possible. This should be done promptly before too much blood has been lost in order to avoid the atony from shock which so often occurs in these cases.

Braxton Hicks' version may be useful in some cases. When the patient is a poor operative risk when the baby is just on the border of viability when conditions are such as to preclude operative intervention this useful procedure should be carried out immediately. The technic consists in dilating the cervix until two fingers can be inserted into the uterine cavity. In cephalic presentation the fetal head is pushed upward and to one side by the intra uterine fingers and the breech is stroked and pushed downward toward the inlet of the pelvis with the right hand assisting abdominally. When the combined version has been accomplished the membranes are ruptured and a foot is grasped by the internal fingers. If difficulty is encountered in grasping a foot an 8 inch forceps may be found useful in bringing it down. As soon as the knee is through the cervical os there is usually sufficient pressure on the placenta to stop all bleeding. Unfortunately there is the danger that similar pressure exerted on the cord

at the same time will stop the fetal circulation. This accident which occurs frequently cannot be avoided and constitutes a serious objection to the method in patients who have living viable babies.

The *Voorhees' bags* are very rarely used in our clinic in cases of placenta praevia. They have the same disadvantages as the Braxton Hicks version and the additional one of introducing a foreign body into the uterus with the attendant danger of contamination. They may be used in cases in which there is a large baby that would offer difficulties for version. The cervix is dilated artificially to admit the folded bag which is carefully introduced after perforating through the placenta or membranes and into the amniotic cavity with a blunt forceps before inflation thus preventing further separation of the placenta. A rather large No. 5 or 6 bag having a diameter of 7 or 9 cm. is used so that the cervix will be practically completely dilated by the time the bag comes out. The hemorrhage is thus controlled until the bag is expelled when the fetus usually follows spontaneously or can be delivered by craniotomy or forceps or version depending on the conditions present at the time of expulsion of the bag.

PREMATURE DETACHMENT OF THE PLACENTA

Premature detachment of the placenta is relatively common in its milder forms. In my experience it is potentially the most serious complication in pregnancy. The mortality in the severe cases is practically 100 per cent for the fetus and 50 per cent for the mother unless she is exceptionally well cared for.

ETIOLOGY—Little is known of the etiology except that the condition is classed as a toxemia associated with decidual hemorrhages which result in irritation of the uterus and complete placental separation in many cases. Multiparas are affected three times as frequently as primiparas. Overdistention of the uterus as in twin pregnancy or hydramnion may be significant after rupture of the membranes or the birth of one twin. Short cord trauma, infectious diseases—all have been said to predispose to premature detachment.

PATHOLOGY—It is important to separate the various cases

into five groups since on the pathologic changes in the uterus in these groups rests the rationale of treatment

Group I Complete Separation in Early Pregnancy—The changes are limited to the placental site. The placenta is peeled off of the uterine wall and is then expelled together

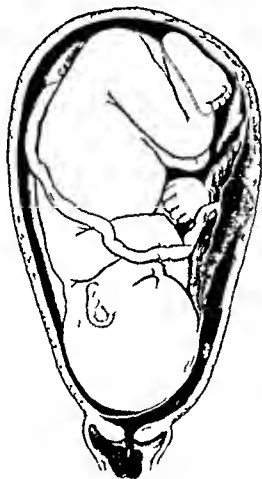


FIG. 13.—Partial placental separation with seven months fetus. Blood clots stimulate uterine contractions. If total or parts complete separation will result in fetal death.

with some clots from the uterine cavity. The uterine wall is unaffected.

Group II Incomplete Separation with Apparent Hemorrhage (Fig. 13)—After the sixth or seventh month if the separation is incomplete and not too extensive the pregnancy may continue to term. When the placenta is expelled the

of the uterus with fetus free in the abdominal cavity has been made. Symptoms of very severe shock and hemorrhage are usually present in these cases and postpartum hemorrhage is greatly to be feared owing to the relaxed and paralyzed condition of the uterine musculature. In Groups IV and V there may be considerable hemorrhage into the abdominal cavity from the tears in the peritoneum and underlying uterine muscle as a result of the overdistention. These tears may continue to bleed even after the intra uterine hemorrhage has been stopped.

Prognosis—The prognosis depends on the type of premature detachment, the surroundings of the patient and the skill and courage of the medical attendant. Maternal mortality figures as given by various authors range from 57 to 50 per cent. The fetal mortality is extremely high, varying from 50 to 85 per cent according to various authors.

Much of the maternal mortality is due to a failure of the attending physician to recognize the seriousness of the condition in the early stages of the separation and the temporizing methods of treatment when radical methods should be employed. Mistakes in diagnosis also contribute to the mismanagement because the treatment essentially must be different from that accorded those conditions most closely simulating this condition clinically.

The high fetal mortality is chiefly due to intra uterine asphyxia before the diagnosis is suspected clinically. It is augmented by the fact that the mother may be toxic and that the fetus is in over 50 per cent of the cases considerably premature and frequently nonviable.

Treatment

The treatment of premature separation of the normally implanted placenta varies greatly in the hands of different authorities. Thus one man advocates a conservative attitude delivering practically all cases from below. Another favors radical intervention as soon as the diagnosis has been made. A third individualizes the cases treating some conservatively and others radically.

We attempt to classify the type of case present and the

pathology involved. We consider especially the age and parity of the patient and the duration of pregnancy and whether or not the cervix is dilated or easily dilatable before determining the course of treatment.

All pregnant women who bleed even a small amount in the later months of pregnancy should be placed at bed rest in a hospital if possible until a thorough examination determines the cause.

In *Group I*, if the separation is complete there is nothing to do but provide the ordinary care of a complete abortion. If the separation is incomplete as in *Group II*, rest in bed and sedatives may prevent further separation. Progestin preparations such as 3 cc of lutein solution four times daily until all active symptoms have ceased then biweekly have proved of value. The fetus may go to viability or even to term at which time the separated area may appear as an old infarct on the surface of the placenta. It is in this group that the nicest judgment has to be exercised as to the degree of separation, the condition of the baby and whether or not the interests of all concerned will best be served by watchful waiting or by radical intervention and if the latter what type of intervention is advisable. If the patient is a primipara and especially if she is an elderly primipara with a viable baby and if the bleeding is more than a spotting or if the baby shows some signs of distress a cesarean section is probably the safest procedure. If the fetus is just on the border line of viability at twenty-eight to thirty weeks and the hemorrhage is moderate and seems to have stopped temporarily morphine and lutein (3 cc t.i.d.) may be given and the patient carried along until the fetus is viable provided she can be kept in the hospital under close supervision and with the understanding that radical intervention will be undertaken at any time that the symptoms of further separation become evident. If these conditions cannot be met the uterus should be emptied as soon as proper conditions can be provided.

If the evidence of detachment first appears when the patient is well advanced in labor the cervix may be dilated and the baby extracted by version or forceps as seems best.

sponds well to stimulation it is not removed but it sewed up and dropped back in the abdomen

If the operating room facilities and proper assistants are not available what then The outlook is gloomy but not hopeless The dilatation of the cervix is the important factor If the patient is a primipara with a resistant uneffaced cervix a No. 5 Voorhees bag may be inserted and traction applied to hasten softening and dilatation As soon as the bag is expelled dilatation should be completed manually or by Duhrssen's incisions and the baby delivered by version if alive or craniotomy if dead and presenting by the head Following the delivery of the baby and placenta in these cases the uterus should be firmly tamponed as described under Postpartum Hemorrhage

In some clinics a Spanish windlass is tightly applied and large doses of pituitrin are administered to force uterine contractions and spontaneous delivery is awaited Good results have been reported but we have adopted the more radical method

The keynote to the management of these cases is *promptness in making the diagnosis* as to the degree of separation and the resultant pathologic involvement and *courage to adopt radical measures* if possible before the development of a desperate situation for the patient To this end persons responsible for the care of obstetrical cases should have a plan of action definitely worked out in their own minds before such a case presents itself Only in this way will the fight for decrease of the frightful mortality as given by certain statistics be won

SUMMARY OF CASES

The value of any procedure or type of treatment can be adjudged best by the results obtained by its application An analysis therefore of our cases over a fifteen year period is of interest The total number of deliveries at the Research and Educational Hospital was 10486 all of which were charity teaching cases Of these 762 have been complicated by the three most common forms of obstetrical hemorrhage with a maternal mortality of 0.39 per cent

There were 133 cases of *postpartum hemorrhage*, an incidence of about 1.2 per cent. Forceps delivery was performed in eleven of these cases or 8.3 per cent. Seventy-two per cent followed spontaneous deliveries and in none was labor induced by medicine. There was one maternal death in the group.

There were fifty-two cases of *placenta praevia* in the total group, an incidence of 0.49 per cent. Of these forty-three were marginal placenta praevia and nine were central placenta praevia. Nine patients, approximately 17 per cent, were delivered by cesarean section and thirty delivered spontaneously. A Voorhees bag was inserted in only three cases. There was no Braxton Hicks version. There was no maternal mortality in this group, but a total infant mortality of 7 per cent.

There were ninety-seven cases showing *premature detachment of the placenta* and in seventy-one or 73 per cent of them spontaneous delivery was permitted. Cesarean section was performed in twenty-three cases or 24 per cent. Version and extraction was done thrice, breech extraction once and vaginal hysterotomy once. The figures indicate that while we believe in cesarean section for cases with extensive separation, we were able to employ conservative management successfully in over 73 per cent of the cases. Our gross fetal mortality in this condition was 20 per cent. Seventy-seven babies, many of which were markedly premature, all lived and left the hospital in good condition and over 5 pounds in weight. There was one maternal death.

We feel that these results are due to a keen realization of the dangers inherent in obstetrical hemorrhages, proper equipment to combat the resultant anemias and an appreciation of the pathology involved in various types of hemorrhages which leads to the application of proper clinical procedure in the individual case.

THE THERAPEUTIC ROLE OF THE ESTROGENS*

M EDWARD DAVIS MD FACST

Natural Estrogens

The estrogenic hormone is one of the two ovarian hormones which has assumed considerable importance in clinical practice. Although the original source of this substance is the developing and mature follicle in the ovary, a number of metabolically changed substances are available from other sources such as blood and urine. All of these active principles obtained from natural sources have been designated as the natural estrogens. Thus we have available *estrone* or *theelin* derived from pregnancy urine, *estriol* or *theelol* derived from the same source, and *estradiol* first recovered from the ovaries of the sow. These natural estrogens all produce the same biologic effects but they vary considerably in potency. Thus estradiol is the most effective and estrone the least effective. In the use of the natural estrogens it is important to take this variation in their potency into careful consideration. These three natural estrogens are available in pure form and in standardized preparations. They can be administered parenterally, orally and by vaginal suppositories. Their effect varies with the preparation selected and the mode of administration. They are most effective on subcutaneous or intramuscular administration and least effective orally.

Synthetic Organic Estrogens

Since 1938 primarily as a result of the work of Dodds, Goldberg, Lawson and Robinson we have available synthetic organic drugs with remarkable estrogenic properties. The best known of these synthetic organic estrogens are derived from

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the stilbene compounds *Diethylstilbestrol* is one of some six substances that have been subjected to adequate trial. These organic estrogens have gained rapid popularity because they can be administered orally with as great effect as parenteral administration of the natural estrogens. They are inexpensive to use. Very careful observations over long periods of time do not reveal any differences in the biologic actions of the natural and synthetic estrogens so that they can be used interchangeably. For the past several years much of estrogenic therapy has been carried out with stilbestrol.

Estrogen Therapy Is Replacement Therapy

Estrogens should be used in those instances where the individual's own ovaries fail to produce the hormone or fail to provide an amount adequate for the needs of the individual. These estrogenic substances therefore should be used in the nature of replacement. When this fundamental principle of endocrine therapy is disregarded the substance administered may lose its character of a hormone and assume that of a drug. Huge unphysiologic amounts of estrogens have been administered with variable results but these practices are not sound endocrinologic practice. In order to determine the proper therapeutic role for the estrogens we must review their normal physiologic roles.

Physiologic Considerations

Estrogens produced by the ovary are primarily growth promoting principles. They reach a sufficiently high level at about puberty to initiate many of the changes which take place at this time (Fig. 15). Under their influence the secondary sex characters begin to differentiate and slowly attain their normal adult female appearance. The typical hair pattern of the lower abdomen and body develops. The breasts increase in size the estrogens promoting the growth of nipples, areolae and duct systems but having little effect on the secretory structures. The external genitalia develop to their normal state. The entire müllerian derivatives are under estrogenic control so that the vagina, uterus and fallopian tubes develop their adult state. The onset of cyclical activity

in the uterus is preceded by the growth of the endometrium as a result of estrogenic stimulation. Ultimately, when maturity is reached and ovulation occurs the endometrium is

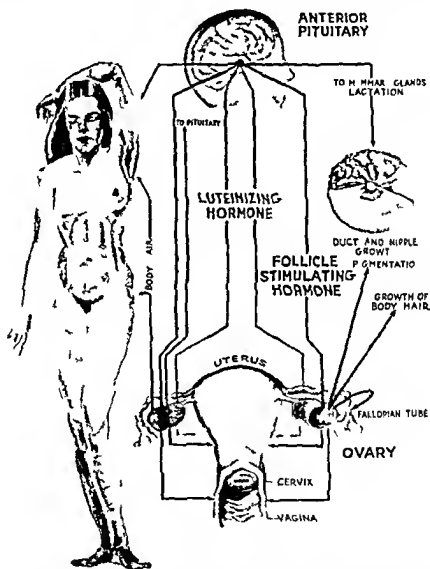


Fig 15—Physiologic role of the ovarian hormones and their pituitary control. The estrogenic or follicle stimulating hormone controls cyclical changes in the entire reproductive tract the ducts and nipples of the breast pigmentation the growth of body hair and epiphyseal closure

converted into a functional phase by the appearance of progestin. Then periodically during the entire reproductive period estrogens promote the cyclical changes that take place

in the reproductive tract Estrogens complete the osseous growth of the skeleton by inducing epiphyseal union The therapeutic application of estrogens should retain their physiologic role as far as possible Thus their hormonal action can be maintained

THE MENOPAUSE

The menopausal syndrome is a condition par excellence for the use of estrogenic medication Although the majority of women do not consult physicians because of menopausal symptoms a sufficient number demand treatment to make this condition a most important one The physiology of the climacteric is not clearly understood but the cessation of ovarian function brings in its wake a bizarre train of symptoms which may completely upset the normal equilibrium of even the well balanced individual The insidious onset of the natural menopause may be less severe than the abrupt onset of the artificially induced one However the gradual cessation of ovarian function is likely to result in a longer climacteric Thus symptoms may extend over a twelve to eighteen month period in the artificial menopause whereas it may last as long as five to six years in the natural climacteric The period of waning ovarian activity may be very troublesome to the patient

Prior to the introduction of estrogens in the treatment of the menopause therapy was unsuccessful It consisted largely of the administration of *sedatives* to combat the nervous and emotional manifestations Some relief could be obtained by dulling the vasomotor mechanism thereby decreasing the frequency of the hot flushes The array of medical suggestions for the relief of this distressing period in the woman's life attests the lack of desirable results

Estrogens were employed in the treatment of the menopause as substitution therapy The extension of our knowledge in endocrinology soon made it apparent that the cessation of ovarian function was followed by an increased pituitary function so that a follicle stimulating gonadotropic substance appeared in the urine Estrogens depress this gonadotropic function of the pituitary gland There is a direct correlation

Artificial Menopause

The artificial menopause has been treated with estrogens with excellent results. It may be well not to wait for the patient to develop ovarian withdrawal symptoms. We have treated many patients who have had no symptoms through their entire menopausal period. The administration of estrogens may be started ten days after castration by surgery or radiation of women during active reproductive years. The patient is given 1 mg. of stilbestrol each night just before bedtime. She should be cautioned to maintain a daily dose for a constant estrogen level is important for well being. The recovery from the operation will continue rapidly and uneventfully and the patient will not be aware of the ovarian withdrawal. She continues this medication for three months at which time the daily dose is cut to 0.5 mg. This amount may be continued for at least six months when a further cut to 0.25 mg. should be instituted, the patient taking a 0.5 mg. tablet every other night. At the end of another three to six months the dose is reduced to 0.1 mg. and ultimately completely discontinued.

This method of administering stilbestrol in the treatment of the artificial menopause has been highly satisfactory. It is our experience that 1 mg. of the drug per day represents complete ovarian estrogenic replacement and any changes should be downward and not upward. If the patient's symptoms are menopausal in origin, 1 mg. per day will bring complete relief. The slow reduction in the daily amount allows for the gradual readjustment which must take place in the patient's endocrine system. It has been our experience that treatment of the artificial menopause may take from twelve to twenty-four months and that the average patient needs therapy for about eighteen months. It is well to discontinue treatment in the winter months when the return of an occasional hot flush is not troublesome.

Natural Menopause

The natural menopause is more difficult to treat because there may be a long period of failing ovarian activity. During these months the patient menstruates irregularly and experi-

ences menopausal symptoms when the estrogens reach a low level. The uncertainty and marked fluctuations in the patient's own estrogens make accurate substitution difficult or impossible. Treatment should begin with small amounts, 0.1 to 0.5 mg daily, and the effect on the hot flashes should be carefully observed. It is logical to administer the smallest amount necessary to keep all the hot flashes in abeyance. The amount of the drug may have to be increased slowly as the estrogenic function of the ovaries reaches a low ebb. Again it has been our experience that no patient will require more than 1 mg of stilbestrol per day. When complete substitution is reached the amount may be slowly reduced as previously described. The natural menopause may require from eighteen to thirty-six months and treatment has to be continued for an average of twenty-four months.

Precautions and Hazards

In spite of the fact that treatment of the menopause is highly successful in over 95 per cent of patients who need therapy, there are some precautions that must be taken and a few hazards to overcome.

In the first place any patient who has *irregular bleeding* as part of the menopausal picture must be carefully examined to make certain that the bleeding is not a symptom of a serious underlying disease. In the absence of gross palpable findings a diagnostic curettage is necessary to rule out an early carcinoma of the corpus of the uterus.

Estrogens occasionally *provoke bleeding* thereby further complicating the clinical picture (Fig. 17). The most common cause for bleeding during the administration of the drug is fluctuations in estrogen level produced by withdrawal of the drug. The continuity of the therapy must therefore be emphasized. Estrogen bleeding can occur on a constant estrogen level and is probably brought about by the proliferative changes in the endometrium. In the event of such bleeding it is well to discontinue medication for several weeks and longer. Bleeding should subside but should it continue a diagnostic curettage may be necessary.

About 12 per cent of patients experience some *nausea* at the

onset of therapy with estrogens. Natural and synthetic estrogens may provoke nausea if they are given in comparable amounts. In most patients the nausea will disappear in a few days if they continue to take the hormone. A rare individual



Fig 17—Biopsy of the endometrium obtained during a bleeding period. The mucosa undergoes moderate proliferation as a result of estrogenic stimulation but continued medication does not result in an increased change

one or two in a hundred cannot take any estrogenic substance even in minute amounts without serious nausea. There is no explanation for this interesting phenomenon.

No untoward symptoms or findings have been observed in well over 1000 patients who have been most carefully ob-

served during the last four years. In some experimental animals estrogens are carcinogenic. However, there is no good evidence that they exert similar properties in the human. The possibility of producing a cancer by their administration in clinical amounts can be regarded as highly improbable.

POSTMENOPAUSAL VAGINITIS

Davis in 1935 first demonstrated the value of estrogens in the treatment of postmenopausal vaginitis. The development of the vaginitis follows an inflammation superimposed upon the atrophic mucosa. The exciting agent may be some minor trauma which injures the thin inactive squamous epithelium. The patient develops a sensation of burning or itching, dysuria and frequency and a serosanguineous or gluey discharge. These symptoms are exceedingly troublesome and annoying. Estrogens rapidly convert the atrophic squamous epithelium into the normal active mucosa of middle life (Fig. 18). These cellular changes result in a rapid disappearance of the inflammation beneath the mucosa and the establishment of a normal biologic flora. The pathogenic organisms disappear and all symptoms subside. At the cessation of therapy regressive changes set in and the mucosa of the vagina slowly reverts to its previous state. However, symptoms of vaginitis will not reappear unless trauma and infection recur.

Estrogens are administered in a small vaginal suppository. Usually 0.5 mg. of stilbestrol is used each night for six to eight weeks. The simplicity of this therapy, the immediate and complete relief provided the patient and the absence of untoward effects make this management ideal.

INHIBITION OF BREAST ENGORGEMENT

It is occasionally desirable to prevent engorgement and lactation following delivery as when the child is stillborn. In other instances the nipples may be so poorly developed that nursing would be impossible. The patient may have had a breast abscess in a previous puerperium and it may be well not to try nursing a second time. Maternal conditions such as tuberculosis or heart disease may make nursing undesirable.

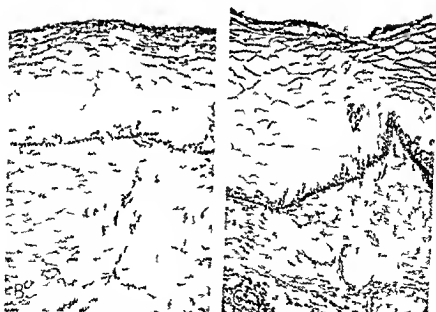
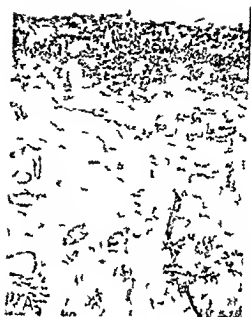


Fig 18—Photomicrographs of the vaginal mucosa in a patient with polymorphous vaginitis before and after treatment with estrogenic suppositories (All photomicrographs are magnified 425 times for accurate comparison)

A Before treatment. The squamous epithelium consists of four or five layers of cells which are small and indistinct. The basal layer of cells is

It is possible to prevent all breast discomfort in all of these circumstances by the administration of an estrogenic drug. If it is administered sufficiently early in the puerperium no engorgement or lactation will take place. The usual practice is to give the patient a 5 mg tablet of diethylstilbestrol immediately after delivery and each day for seven or eight days. No binder or breast care is necessary.

In the event that nursing has commenced and has been maintained for some days or weeks stilbestrol is no less effective. The breasts return to their normal state within forty-eight hours after the beginning of therapy. No binder, ice cap or limitation of fluid is necessary. In a small group of patients a very slight secretion of milk will recur after the cessation of treatment. This recurrence is neither troublesome nor does it demand treatment.

PRIMARY AMENORRHEA

The onset of menstruation or puberty heralds the advent of adolescence and sexual maturity. Normal physical feminine development and the capacity for reproduction depend on normal reproductive organs which function as a result of a closely correlated endocrinal relationship. In some young women menstruation fails to take place. Although this failure is only one manifestation of an abnormal reproductive mechanism it provides the name of primary amenorrhea.

The absence of the menses in a young woman may be the result of a lack of normal development of all or a part of the

somewhat irregular. There is no sharp demarcation between the cells and the subepithelial zone. No mitotic figures can be seen. A moderate infiltration of round cells and a few polymorphonuclear leukocytes can be seen in the subepithelial zone indicative of the inflammatory condition.

B Four weeks after the daily administration of a 0.5 mg stilbestrol suppository vaginally. Note the complete restoration of the squamous epithelium to that seen during active sex life. The basal cells are arranged regularly and show signs of cellular activity. All of the cells are large, clear, sharply demarcated and contain an abundance of glycogen. The functionalis is beginning to develop. Note the increased vascularity of the subepithelial connective tissue and the complete disappearance of inflammatory cells.

C Eight weeks after the onset of treatment. Note the increasing thickness of the squamous epithelium. The functionalis has been completely restored. The active basal cells comprise several layers.

reproductive tract. The uterus may be underdeveloped or rudimentary or its canal may be nonpatent. The vagina may be absent or its lumen may fail to provide continuity with the uterus. The gonads may be absent or abnormal. The menstrual function may be absent because of an endocrinal failure pituitary or ovarian in origin. The anterior lobe of the pituitary provides the motor for the cyclical changes which take place in the reproductive organs. Pathologic conditions in the pituitary gland may hold these changes in abeyance or completely inhibit them. The ovaries may not be responsive to normal pituitary stimuli because of abnormal development thereby resulting in uterine inactivity. While it often is possible to determine which of these factors operate in a woman with primary amenorrhea it may or may not be possible to correct or remove the cause.

A lack of normal development of the sex function may have a profound effect on the physical, psychic and even mental development of the young woman. In some of these persons puberty and the changes it initiates are delayed into adulthood. Thus the bony skeleton may fail to develop normally as a result of delayed epiphyseal closures. Secondary sex characters which differentiate the woman from the sexless child may all be absent and the normal feminine figure fails to evolve. Associated with this lack of physical development there usually occurs a retarded psychic development which results in an abnormal social adjustment. The young woman may begin to brood over her physical and sexual inequalities. She magnifies their importance to such an extent that she develops an inferiority complex, a temporary or permanent psychosis or abnormal sex relationships. Menstruation therefore although only one index of functioning reproductive organs becomes of paramount importance to these young women with primary amenorrhea.

Obviously in the presence of only rudimentary portions of the mullerian derivatives or in their complete absence vaginal bleeding is impossible. On the other hand when a lack of normal development of these organs is present or an abnormal endocrinal relationship interferes with normal sex activity improvement and perhaps a restoration to the normal

is theoretically at least possible. Every advance in endocrinology has offered one more challenge to find a solution to some of these interesting problems.

Theoretically at least in many of the patients with primary amenorrhea *gonadotropic substances* which supplant the action of the normal anterior lobe of the pituitary gland should prove efficacious. These gonadotropins should stimulate the ovaries to normal cyclical activity so that these structures can produce the hormones necessary for endometrial growth secretion and menstruation. It has been found, however, that impure gonadotropic substances from pregnancy urine and from gland extracts have little effect on the human ovary. Equine gonadotropin more nearly reproduces the action of the normal pituitary gland and is the most potent of our gonadotropic principles. Some results have been obtained with pregnant mare serum in the treatment of primary amenorrhea but in the majority of instances the treatment has been unsuccessful. It is possible that the ovaries of these women are primarily at fault. Their ovaries may be so abnormal or undifferentiated that they are refractory to stimulation by the pituitary gland in which event gonadotropic therapy is doomed to failure.

The administration of estrogens must be considered as purely substitution therapy. The *natural estrogens* can bring about the development of the reproductive organs, the breasts and the secondary sex characters. To accomplish this however estrogens must be administered in comparatively huge doses intramuscularly and at frequent intervals to maintain a constant level of blood estrogens. On the withdrawal of this hormone regressive changes begin so that after a short time the structures revert to almost their previous state.

Stilbestrol has provided an ideal estrogen for the treatment of this condition. The daily oral administration of a small amount provides a sufficient estrogenic stimulus to produce physical and sexual maturity of these underdeveloped young women. The changes induced in these patients in a short period of a month or more are truly astounding.

The following case history is typical of the group of young women with primary amenorrhea.

S. B. now twenty four years of age had never menstruated when she came to our clinic in 1936 at the age of eighteen years. She had been treated elsewhere for her amenorrhea since 1934. At eleven years of age a scanty growth of pubic and axillary hair

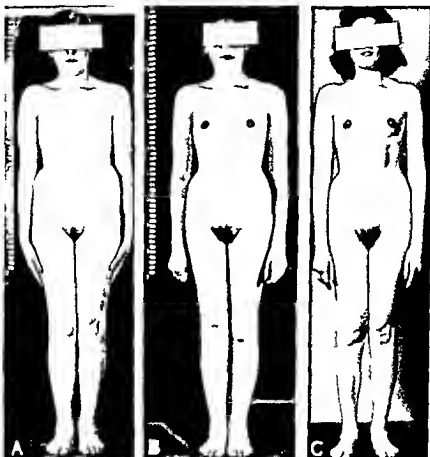


Fig. 19—A S. B. before treatment of therapy. B After 18 months of treatment. C After 3 years of treatment. Note the development of the breast. Not the normal mature female development of the secondary sexual characteristics.

had appeared but no further secondary sexual development occurred and she retained the square shoulders, narrow and boxlike hips and juvenile facies of the prepubertal girl.

When first seen by us in 1936 her appearance was typically pre-

adolescent There were practically no breasts and the pale areolae measured only 8 mm in diameter Tiny flat nipples resembled those of a six year old child The pubic and axillary hair was

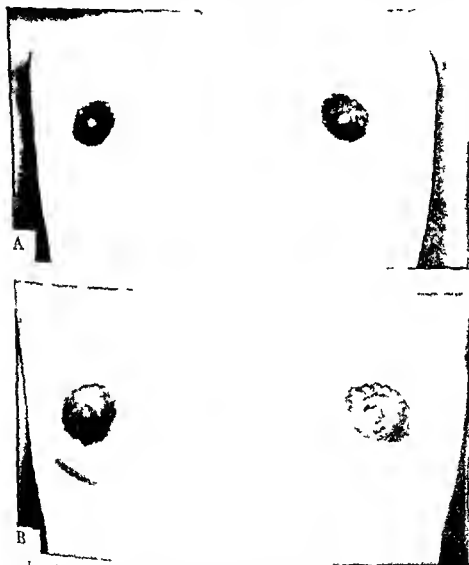


Fig 20—A Breast development after six months substitution therapy with estrogens The breast development is largely growth of the duct system the areolae and the nipples The pigmentation of the areolae is striking B Breast changes after three years of substitution therapy The appearance of the breasts has not changed after the first year of therapy The striking changes resemble those seen in pregnancy

thin and sparse the labia were almost nonexistent and the vagina which admitted a finger tip with difficulty was narrow short and smooth walled The uterus was small and consisted mostly of

cervix. No adnexa could be palpated. Basal metabolic rates ranged between minus 9 and minus 17 per cent. The visual fields were normal. X-ray studies revealed normal epiphyses with delayed closure in the proximal phalanges. There was no abnormality of the sella turcica.

From 1936 to 1938 the patient received mainly gonadotropic preparations, latterly supplemented by parenteral administration of natural estrogen in single doses of 20,000 to 100,000 I.U. preceding courses of equine gonadotropin. No vaginal bleeding and very little change in the patient's physical state occurred.

On May 1, 1939, the patient was placed on a dosage of 1 mg. of stilbestrol by mouth daily, and she has continued this routine dose with occasional brief rest periods to the present time. There has been no intolerance. Except for a sharp and permanent increase in the hemoglobin level from 8.8 to 13.8 gm. per 100 cc. of blood, with cell volumes respectively of 25 and 41 per cent, there have been no significant changes in laboratory findings. Very striking changes in the appearance and personality of this patient occurred within four months, as the photographs show (Figs. 19 and 20), and the patient has menstruated at intervals of from four to eight weeks, usually requiring withdrawal of the stilbestrol to invoke bleeding. The breasts and external genitalia are now entirely normal in appearance except for marked pigmentation about the nipple and in the linea abdominalis. This pigmentation is of great interest and its significance and mechanism of formation is being investigated at the present time. The patient's outlook on life has improved immeasurably.

Comment

Many interesting observations have been made concerning the treatment of patients with primary amenorrhea. Stilbestrol completely replaces the estrogenic activity of the ovary. It produces sexual maturity in the immature female with the exception of ovarian function. The prepubertal state is rapidly replaced by the physical and organic development of the mature woman. All of the secondary sex characters develop. The reproductive organs assume the normal adult type. The undifferentiated juvenile physical characteristics give way to the mature feminine form. The speed of the transition is remarkable, for all this is accomplished in a period of several months, whereas normal adolescence requires three or four

years. The gonads are the only reproductive organs that are not affected and remain dormant.

It was possible to produce some of these changes by means of the natural estrogens when they were administered at frequent intervals and in large doses. It has not been possible, however, with the natural estrogens to produce the degree of physical and sex development seen in women with primary amenorrhea who were treated with stilbestrol. Furthermore it has been impossible with the natural estrogens to maintain the development for long periods of time so that the patient would be benefited by the change. The natural estrogens were administered intramuscularly at varying intervals and for short periods of time. This mode of medication probably resulted in varying concentrations of blood estrogens not conducive to optimum results. On the other hand, oral medication can be easily maintained over long periods of time thereby producing a constant estrogen level in the blood and tissues.

Obviously this substitution therapy must continue in order that these young women remain normal. When natural estrogens only were available continued therapy was impossible and undesirable. Now that it is possible to take a small tablet of stilbestrol once a day or less often prolonged substitution becomes entirely feasible. There can be no question as to the desirability of continued therapy in these young women, provided this therapy is safe and no injurious effects occur. Only careful clinical observations and experimental studies over long periods of time will answer these questions. No one doubts the wisdom of continued substitution therapy in hypothyroidism, in diabetes and in other glandular deficiencies. Why should one doubt the wisdom of continued therapy in hypogonadism?

The amount of stilbestrol necessary to maintain the optimum development of the individual is difficult to ascertain. Larger amounts of the drug are necessary during the transitional period but small amounts may suffice to retain the desired changes. About 0.5 mg. daily has been sufficient to prevent any regression and it is entirely possible that this amount is too large. Careful endocrinal assays may reveal the

DELIVERY ROOM SET UP DURING WARTIME*

EDWARD L CORNELL MD FACS†

THE shortage of help in all departments of the hospital during wartime necessitates the elimination of all unnecessary employment of linen and supplies. With this in mind I shall endeavor to describe the set up used at Henrotin Hospital and found very satisfactory.

Two methods are commonly employed in the delivery of a patient, one termed the flat set up and the other the stirrup set up. The former is used in most hospitals for patients who have not had analgesia or who are not to be delivered by forceps. Many of these patients are later put in stirrups because forceps delivery or repair work following an episiotomy or tear requires better facilities for work than the flat position provides. This change requires or should require a new sterile set up thus necessitating the use of more linen and resulting in wasted effort and time. Incidentally the change over means that the patient is kept under anesthesia longer than would otherwise be the case.

I believe I am correct in stating that nearly 75 per cent of all women in labor require either instrumental delivery or repair of lacerations of the cervix or vagina. Stirrup delivery is indicated in all these eventualities. Adding to these the instances in which stirrups are required for the analgesic patient who is difficult to control during the delivery of the baby, we find the percentage of stirrup set ups rising close to 90 per cent.

As so many of the patients in our hospital would normally require the stirrup set up for delivery I ask that all patients be delivered using it. In other words we make no attempt to cull out the patients who might be delivered in the flat

From Henrotin Hospital Obstetrical Service

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Fig. 23—This shows the set up of the instrument table and the baby receiving table. The baby part of the former is covered with flannel cover slip. A heavy padding is used underneath the canton flannel sheet on the table. The instruments are self explanatory. You will not see the baby receiving table at this time extended entirely round the table top. This prevents the baby from rolling off. The table can be moved in any position and after the cord is severed the baby may be placed under the heating lamp without removal from the table. It does not have to be attached because it cannot roll off.

The stirrup set up reduces the number of persons necessary to man the delivery room to a minimum of four—the attending physician, one clean nurse, one circulating nurse,

and the anesthetist. You will note that I do not mention the intern or resident because already there is scarcity of both. During World War I there was one intern for 120 beds at the old Chicago Lying in Hospital. With this minimum set up the patient can be delivered safely under sterile conditions and all repair work can be done without further change in the arrangements except for the addition of two large towels as shown in Figure 21.

We use the split type of delivery table therefore, the patient has bars on which to pull with the bearing down pains (Fig. 22). The position of the patient permits the physician to listen to the fetal heart tones at any time using the head stethoscope without contaminating the surgical field. After the delivery the vagina and cervix can be inspected easily for lacerations and all repairs done employing the clean nurse as an assistant if no intern is available.

The baby is placed on a small table (Fig. 23) which is on rollers and which can be wheeled in front of the operator leaving the cord still attached. This table on all four sides has a bar elevated about 3 inches above the top to prevent the baby from rolling off. The table is covered with a sterile cotton flannel half sheet and a large sterile towel which later is removed before the baby is placed in the sterile baby receiver. The towel catches the bloody secretions and mucus leaving the receiver clean. The cord is cut and taped with the baby lying on the table. The binder is put in place and the eyes are treated after which the baby is turned over to the circulating nurse. This baby receiving table is well adapted to the treatment of an asphyxiated infant, since it enables the obstetrician to use a tracheal catheter or a bulb syringe without contaminating himself.

TECHNIC FOR CESAREAN SECTION

The Obstetric Department at Henrotin Hospital decided that all patients requiring cesarean section provided no infection was present and all clean cases of ectopic pregnancy and abortion should be cared for in the Obstetric Department and not in the Surgical Department as is done in many general hospitals. Consequently the equipment for the delivery

rooms was set up with this in mind and the personnel was trained in operative surgical technique in other words the student nurses and supervisors must have surgical training before coming to the Obstetric Department. When the tables were purchased for the delivery rooms we had in mind their use as operating tables as well as delivery tables. We decided



Fig 24—The delivery table shown in figure 24 is a Scanlan Morris table. The sterile sheets are placed around the leg. A firm roll is placed across the upper abdomen, chest and over the nethetic bag. The leg sheet is placed over all. A heavy piece of Turkish towel is placed under the patient.

upon the Scanlan Morris delivery table the upper end of which meets all the requirements of a surgical table. It can be elevated or lowered to suit the height of the operator.

For cesarean sections we remove the lower end of the table and use the leg supports which hold the patient's legs in a very comfortable position. The set up (Fig 24) is somewhat

different from that usually employed for surgical operations. In draping the patient, a sterile sheet is used over each leg, a sterile sheet across the upper part of the patient and over the anesthetist's guard and another one across the legs and the lower part of the patient. These last two sheets are draped along the side of the patient so that only the abdomen is exposed. Then the usual divided surgical sheet is placed over all. The operator stands on one side of the patient, the first assistant on the other, and the second assistant between the legs (Fig. 25). Hence the operators are not in each other's way. Two scrub nurses and two service tables are used.

The first service table contains the following list of instruments:

INSTRUMENTS FOR CESAREAN SECTION

24 needles	1 abdominal retractor (DeLee Universal)
1 knife blades	1 flexible ribbon retractor
2 scalpels	Thumble (2 pieces)
2 straight needles	Shuttle
8 towel clips	2 retractors (abdominal spatula flat)
8 straight towel clips	24 rings
10 straight hemostats	18 Allis forceps
1 uterine ring forceps	3 8 inch curved Ochsners
10 sponge sticks	4 9 inch curved hysterectomy forceps
4 tissue forceps—2 with and 2 without teeth	2 10 inch curved forceps
Bandage scissors	4 vulsella forceps
2 curved scissors	1 packing forceps (DeLee Special)
2 needle holders	
2 8 inch straight forceps	Extras
1 10 inch sponge forceps	Hypo syringe and needle
White and black silk	scissors—curved and straight
2 Parker skin retractors	2 eye retractors
1 pair low forceps	
1 lateral (DeLee) retractors	

The second table contains the gowns for the operator and personnel, linen supplies for the patient and sponges of all types. Upon delivery the baby is placed on a table as described in a previous paragraph. A small table is set up on which are supplies for dressing the cord, resuscitation and treating the baby's eyes. The table is covered with a small sterile pad and a sterile sheet.

There is a small instrument table used by the operator

Over it is a small pillowcase on one surface of which there has been sewed a piece of padding large enough to cover the entire top of the table and to drop over the sides for 3 inches. On the back of this pillowcase is fastened a heavy towel which is kept in place by towel clips. This enables the sterile



Fig. 25—A side view of the cesarean section table showing the different layers of sheets and the hand straps. The shoulder piece is not shown. The operator stands on one side, the first assistant on the other, and the second assistant stands between the legs. This gives adequate room to work.

nurse to elevate or lower the instrument table without contaminating herself. The service tables are all covered with pads as described in a previous paragraph.

A suction pump which has a 2 gallon jar attached to the side is used to remove liquor amnii and blood from the site of operation. If the rubber tubing is large enough and the suction is raised to the highest vacuum, it will keep the field completely clean so that the operator does not need to work blindly. A special tube for the suction pump was devised by Dr. DeLee which permits the use of rubber tubing $\frac{3}{4}$ inch

in diameter. The suction pump is a piece of apparatus I would not be without in doing a cesarean section. The precaution should be taken to obtain a spark proof pump and motor, especially if it is to be used in the presence of gas anesthesia.

THE USE OF LOCAL INFILTRATION ANESTHESIA IN OBSTETRICS AND GYNECOLOGY

J P GREENHILL MD FACS

It has long been recognized that inhalation anesthetics are dangerous for persons with serious medical ailments such as respiratory infections heart trouble kidney disease high blood pressure severe anemia and diabetes. Some other form of anesthesia must therefore be employed for these patients. All surgeons agree that the safest form of anesthesia in the presence of serious disease is local, infiltration anesthesia. If local anesthesia is the safest for sick persons it seems reasonable to conclude that it is safest for all who require surgery.

If the mortality and morbidity due to general anesthesia were insignificant in apparently healthy individuals who require surgery, there would be little argument in favor of the use of local anesthesia. But, as I shall soon prove, there are distinct dangers connected with general and spinal anesthesia. The latter, while most useful in general surgery and in gynecology, is the most dangerous of all anesthetics for pregnant women. Cosgrove does not agree with this statement because he has obtained excellent results with this form of anesthesia. However, deaths on the operating table from the use of spinal anesthesia are not uncommon and close calls occur in the hands of even its most enthusiastic advocates. One of the chief reasons for the great danger of spinal anesthesia in pregnant women is that during labor pains the cerebrospinal fluid in the lower spinal canal is pressed up toward the medulla, causing respiratory paralysis.

To my mind there are only two reasons for the limited use of local anesthesia in obstetrics and gynecology. The first

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is that most obstetricians and gynecologists are satisfied with the results of general and spinal anesthesia in spite of the complications which can and do occur. The second reason is a disinclination on the part of many obstetricians and gynecologists to read the few essential details about local anesthesia and to make the effort to use it. This much is certain. Nearly everyone who learns the technic of local anesthesia and uses it a few times becomes enthusiastic about it. Evidence of this is the constantly increasing number of articles on the subject now appearing in the literature of obstetrics and gynecology.

DISADVANTAGES OF GENERAL ANESTHESIA

1 There is a slight but definite mortality accompanying its use.

2 There is risk of postanesthetic pneumonia and other pulmonary complications.

3 Acidosis and alkalosis may result from prolonged anesthesia.

4 Shock may follow a long anesthesia.

5 Dehydration is common after prolonged anesthesia.

6 There is a lowered resistance of the peritoneum to infection after its employment.

7 It has a toxic effect on the liver and other vital organs. This makes inhalation anesthesia especially bad for women who have toxemias of pregnancy.

8 There are frequent gastro intestinal disturbances after operation especially vomiting, distention and gas pains.

9 There is an indirect morbidity due to the tendency to mishandle tissues in an operation under general anesthesia. This may lead to complications such as thrombosis and embolism.

DISADVANTAGES OF SPINAL ANESTHESIA

1 There is a definite mortality accompanying its use. Generally the deaths occur shortly after the injection of the anesthetic and the fatalities are usually attributed either to respiratory paralysis, to the position in which the patient is placed after the injection, to a fall in blood pressure or to circulatory changes. Deaths may occur many days after the

injection, however and still be due to this form of anesthesia as may be proved by a study of the central nervous system

2 The incidence of pulmonary complications is at least as high as after inhalation anesthesia. In fact, Brown and Debenham found that pulmonary complications, especially atelectasis, occurred 4.29 times more commonly after spinal (subarachnoid) anesthesia than after inhalation anesthesia in spite of the fact that more 'bad risk' patients were operated upon under general anesthesia. The reasons for this are as follows. First, spinal anesthesia definitely inhibits the depth and force of respiratory movements not only during the operation itself but also for some time afterward. It is these respiratory movements which tend to rid the tracheobronchial tree of foreign matter or secretions. Second, the normal viscosity of the secretions of the tracheobronchial tree appears to be increased after spinal anesthesia hence these secretions are more tenacious. Third, the patient tends to remain quiet for a few hours after an operation performed under spinal anesthesia. As a result, there is a greater possibility for the material in the tracheobronchial tree to obstruct a bronchus with the subsequent development of atelectasis.

3 There is a definite toxic effect on the spinal cord and the spinal nerve roots which is manifested both clinically and pathologically (Lindemulder). There may be early and temporary effects such as headaches and mild paralyses of the oculomotor and abducens nerves. The late effects which may appear months and years afterwards are paralysis of the sphincter ani and incontinence, spastic paralysis and paraplegia.

4 There is frequently a pronounced fall in blood pressure which may prove harmful.

5 Headaches both temporary and persistent frequently occur after operation.

6 The uterus may fail to relax when relaxation becomes necessary.

7 Pregnant women are especially susceptible to complications after spinal anesthesia, just as most women with advanced pregnancy react to various drugs such as suprarenalin in an abnormal manner.

8 Spinal anesthesia is more difficult to use in pregnant women at term because the back cannot be bent properly

9 There is a small percentage of failures

10 In some instances the danger of spinal anesthesia is greater than that of the operation itself

11 Special knowledge is required both for the injection of the drug and the recognition and treatment of complications

12 It is hazardous in women with anemia cardiac decompensation and those in shock

ADVANTAGES OF DIRECT INFILTRATION ANESTHESIA

1 There is practically no mortality due to this method

2 There are no pulmonary complications directly attributable to the procedure This is of special importance in the delivery of women who have eclampsia and preeclampsia because these patients are particularly susceptible to pneumonia One of the chief reasons for the absence of pulmonary complications is the fact that the lungs are well aerated not only during delivery or operation but also afterwards

3 There are no local or general complications There are only three possible sources of trouble and fortunately I have never seen even one A needle may break during an injection especially if an old or rusty needle is used To prevent this only good needles should be employed Furthermore since a needle always breaks near the hub one should never insert the needle its full length The second possible source of trouble is the injection of the solution directly into a vein This might cause disturbing symptoms which fortunately last only a short time To avoid this one should before injecting the solution into any area always pull up on the plunger of the syringe to see if any blood is drawn into the barrel of the syringe If blood is seen a new area must be selected for the injection Furthermore the needle should be kept in constant slow motion while the solution is being injected The third possible complication is an idiosyncrasy to novocain but fortunately this is rare

4 The technic is simple and may be employed in a home as well as in a hospital

5 There is no bad effect on such vital organs as the liver, lungs heart, circulatory apparatus and central nervous system

6 No special knowledge is required The physician himself carries out the procedure and he is therefore not dependent upon another individual This is very important in the present emergency

7 No special after care is required

8 There is a striking reduction of bleeding in the field of operation so that the amount of blood lost is almost negligible

9 There is no interference with the action of the uterus, of the abdominal wall or of respiration

10 Gastro intestinal symptoms after operation are uncommon

11 Patients may take liquids and carbohydrates before during and after operation

12 There is absence of asphyxia of the child such as may occur after the use of a general anesthetic

13 Local anesthesia enables one to operate upon very sick persons and upon old ones

14 There is seldom need to hurry through an operation

15 The tissues must be handled gently, and this is advantageous to the patient

16 There is less wound infection, because trauma is diminished and the patient's general resistance has not been lowered

17 Electrical apparatus such as the cautery may be used without fear of an explosion

18 Minor operations may be performed in the physician's office

19 Local anesthesia is much cheaper than any general anesthetic

CONTRAINDICATIONS TO LOCAL ANESTHESIA

1 Local anesthesia cannot be used if the site where the solution must be injected is infected or inflamed

2 This form of anesthesia should not be attempted in a woman who is exceedingly highstrung and has an almost mor

bid fear when she is told her operation will be performed under local anesthesia. Fortunately there are only a few women of this type. Their number can be reduced still further by the proper preparation of patients for this form of anesthesia. After all local anesthesia is a relatively new procedure and patients believe that they will see their operation performed and that they will hear all that goes on in the operating room. A proper preparatory talk on the part of the operator is essential. The patient should be promised that her eyes will be covered so she will not see anything around her that the conversation she will hear will not be gruesome or disagreeable, that the rattle of instruments and pans will be reduced to a minimum and above all that if she feels much pain and so desires it a general anesthetic will be administered to her. The surgeon should live up to his promises throughout the period of the operation or the patient may lose confidence, become hysterical and demand a general anesthetic.

3 Infiltration anesthesia should not be employed if sulfonamides are used locally because procaine inhibits the action of these drugs.

INDICATIONS FOR LOCAL ANESTHESIA

1 The notion is still too prevalent that local anesthesia should be used only when there is some contraindication to the employment of general anesthesia. Therefore persons with cardiac or renal disease, pulmonary complications, severe diabetes, toxic goiter, marked anemia and those well advanced in years are the ones chiefly selected as candidates for local anesthesia. In obstetrics the women especially chosen for local anesthesia are those who have toxemia of pregnancy, notably preeclampsia or eclampsia.

Obstetric operations which may be performed under infiltration anesthesia are the following:

1 Dilatation and curettement for incomplete abortion, therapeutic abortion, hydatidiform mole, missed abortion and so on.

2 Spontaneous delivery.

3 Episiotomy and repair.

- 4 Repair of childbirth lacerations, both recent and old
- 5 Low forceps delivery
- 6 Cesarean section, classic or cervical type
- 7 Porro hysterectomy
- 8 Anterior vaginal hysterotomy (vaginal cesarean section)
- 9 Sterilization, abdominal and vaginal

In gynecology not only should the "poor risk" patients and old women be operated on under local anesthesia but also many who are in good condition. The gynecologic operations which may be carried out under infiltration anesthesia are

- 1 Dilatation and curettement
- 2 Plastic operations on the vagina and perineum
- 3 Manchester operation
- 4 LeFort operation
- 5 Vaginal hysterectomy
- 6 The Watkins Wertheim interposition operation
- 7 Abdominal operations including salpingectomy, oophorectomy and hysterectomy

PREPARATION OF LOCAL ANESTHETIC SOLUTIONS

All local anesthetics must have a molecular concentration equal to that of the blood and body fluids, corresponding to 0.9 per cent sodium chloride solution. Distilled water is frequently used as a solvent for novocain but a 1 or 2 per cent novocain solution made up in distilled water is markedly hypotonic. As emphasized by de Takats such a solution hemolyzes red cells, ruptures connective tissue and fat cells and produces tissue necrosis. Clinically, one observes a marked induration of the subcutaneous tissue, with prolonged hyperemia of the skin or even breakdown of a perfectly aseptic wound. For these and other reasons *distilled water must not be used as a solvent for local anesthetics*. Nor should tap water be used. Normal salt solution is readily obtainable and must be used.

De Takats points out that novocain solutions are usually oversterilized and because of this are less effective. Heating of any kind, whether boiling over an open flame in a water bath or in an autoclave, diminishes the anesthetic properties

of novocain. Therefore stock solutions in sterile ampules should be used especially in the home. Novocain can be obtained in 1.5 and 5 cc ampules each containing 70 per cent novocain and may be readily diluted with sterile normal saline solution just before the operation. To produce a 0.5 per cent solution of novocain 60 cc (2 oz) of normal saline is added to the 1.5 cc ampule. To obtain a 1 per cent solution 30 cc (1 oz) of normal saline is added to the 1.5 cc ampule of novocain. The 5 cc ampules contain 1 gm of novocain. Hence to obtain a 0.5 per cent solution 200 cc of normal saline must be added and to make a 1 per cent solution 100 cc of normal saline is added.

Adrenalin 1:1000 should be added to the novocain solution with a sterile medicine dropper just before the solution is to be used. 3 drops of adrenalin for each ounce of solution. The adrenalin should be kept in a sterile container. If the adrenalin has a yellow or red brown appearance it is decomposed and should be thrown away.

TECHNIC

The chain of local anesthesia consists of the operator, his assistants (including physicians and nurses), the patient and the local anesthetic. The most important link in the chain is the operator himself. He must first of all convince himself that local anesthesia is the safest and simplest of all anesthetics. He must learn the simple technic and above all he must be willing to sacrifice the extra time and physical and mental effort which operations performed under local anesthesia demand.

Needless to say the surgical preparation of the vagina is the same as that when inhalation anesthesia is used. In nearly all cases the patients are given a hypodermic of morphine ($\frac{1}{2}$ grain) and scopolamine ($\frac{1}{100}$ grain) fifteen minutes before infiltration of the local anesthetic is begun. We have never seen any harm to the mother or the baby from this procedure. The babies which seem to show the evil effects of morphine are those which are delivered two to four hours after their mothers received the drug. The narcosis caused by morphine persists for a variable length of time after the

operation is ended and thus usually insures that the patient will sleep or at least suffer no pain for some time after the operation.

The patient should be made as comfortable as possible during the operation. When feasible someone should sit at her head fan her face if she feels warm place cracked ice in her mouth if she is thirsty, and encourage her from time to time if this is necessary. The operator likewise should talk to the patient occasionally.

For the local anesthetic 0.5 per cent procaine hydrochloride (novocain) is used although 0.25 per cent is almost as effective. For small vaginal operations such as episiotomy, repair of lacerations dilatation and curettement, and low forceps operations not more than 4 ounces is necessary. It is advisable to make up a little more solution than is usually necessary.

Dilatation and Curettement

For dilatation and curettement a narrow retractor is used to depress the posterior vaginal wall gently. If the patient has a narrow vagina or a rigid perineum some solution should also be injected into the perineum in the manner described in the technic for spontaneous delivery. The cervix is grasped with a tenaculum and gently pulled down and to the right side. Then the needle, which should be long and flexible is inserted in the left parametrium by following closely along the cervix for a distance of 2 to 3 cm (Fig. 26). If any resistance at all is met the needle has probably penetrated the cervix. In this event it should be pulled back slightly and then inserted a little more laterally. After the needle is in the parametrium, the plunger should be pulled up slightly to be certain the needle has not entered a blood vessel. If no blood appears in the barrel of the syringe about 10 cc. of solution is injected slowly while the needle is constantly but gradually withdrawn. The same procedure is carried out on the right side of the cervix.

The novocain in the parametria blocks the large sympathetic ganglions of Frankenhauser situated at the sides of the cervix. The local anesthesia produces blanching of the vaginal

mucosa around the cervix. If parts of the vaginal epithelium are not blanched about 5 cc of solution is injected into the space between the cervix and the bladder and between the cervix and the rectum. It is a good plan to inject 10 units of

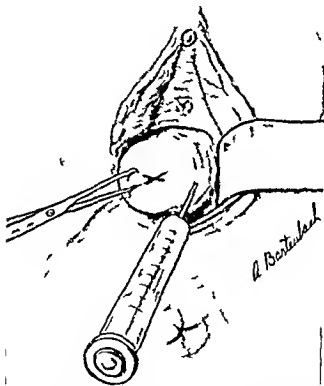


Fig 26—Infiltration of left parametrium with local anesthesia. Cervix is gently pulled to right and needle is inserted in parametrium by following closely along cervix for 2 or 3 cm. After needle is in parametrium plunger of syringe should be pulled up slightly to be certain that needle has not entered a blood vessel before injecting the solution (DeLee and Greenhill Principles and Practice of Obstetrics.)

obstetric pituitary extract into one lip of the cervix when the operation is begun to insure a minimal loss of blood from the uterus.

After about five minutes the cervix is soft enough to permit easy dilatation without pain. Curettement is likewise a

painless procedure and there is little bleeding. The uterus retains its tonicity even if pituitary extract is not used. Occasionally the patient experiences slight pain when the corners of the uterus are curetted.

Spontaneous Delivery

For spontaneous delivery the injection is not begun until the head appears at the vulva in the second stage of labor. To obtain a painless delivery it is necessary to infiltrate the lower half of the vulva, the fascia over the levator ani muscles, the levators themselves, and the perineal body. In some cases especially when the fetal head is large it is necessary to infiltrate the ischiorectal fossa on each side. To accomplish all this the needle is inserted about midway down one labium majus and the solution is injected all along the edge of the labium then across the fourchet and up the edge of the other labium majus (Fig. 27). Usually the needle must be removed and reinserted a few times but one must always reinsert the needle in an area which has already been infiltrated. With Allis forceps slight traction is then made on the infiltrated fourchet and solution is injected between the vaginal wall and the rectum not only in the midline but also well out to the sides in the shape of a fan. The needle is inserted about 6 cm. in each direction and about 30 cc. of solution is distributed in this space. Then the needle is inserted deeply through the fascia over one levator ani muscle and about 10 cc. of solution is injected into the muscle and the fascia. This is repeated on the other side. In a few minutes examination reveals relaxation of the entire perineal floor and gaping of the vaginal outlet. Because of this the patient does not experience the forcible stretching of the perineum which most primiparas do.

The second stage is shortened if there is no interference with the uterine contractions. The head passes through the outlet without pain. If there is a breech presentation, spontaneous delivery may be accomplished or manual aid may be rendered with little discomfort. In some cases labor pains slow down after the infiltration and it is necessary to apply low forceps or give 1 unit of pituitary extract. Perineal lacer

rations are reduced in number and size and there is less need for episiotomy. If a laceration occurs it may readily be sutured without the addition of any local anesthetic in the majority of cases.

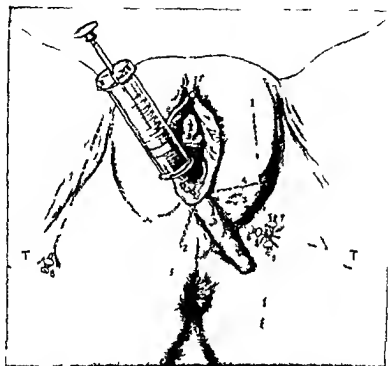


Fig. 27—Areas to be infiltrated for episiotomy. Enter needle in fourfold concentration (1% per cent procaine) in sections 1-2-3 then No. 4—subvaginal. For low forceps operation the pelvic nerves must be blocked to No. 5 long external perineal 6 internal pudendal (the finger is inserted into vagina or rectum to find the space and orient the needle) 7 the branches of the fourth sacral in the ischioanal fossa 8 the lesser satellite along the ramus pubis. Both sides must be blocked. Use no more than 5 ounces of 1% per cent solution (DeLee and Greenhill, Principles and Practice of Obstetrics.)

Episiotomy and Low Forceps Delivery

For an episiotomy the solution is injected as just described for a spontaneous delivery. In addition however more solution must be injected under the skin and vaginal mucosa in the direction of the proposed cut. When the child is large

or low forceps is to be used it is best to inject about 10 cc in each ischiorectal fossa between the anus and each ischial tuberosity, penetrating to a distance of about 5 cm. While doing this it is best to keep two fingers in the vagina to guide the needle. Injection into the ischiorectal fossa results in loss of pain sensation, but the sensation of touch persists. Hence the stimulus to bear down remains. The patient is not afraid to bear down because there is no pain associated with it.

Repair of Lacerations

If lacerations occur in cases where no anesthesia at all has been used it is only necessary to infiltrate the edges and adjoining tissue of the lacerations to repair them painlessly. If old perineal lacerations are to be repaired after the baby is born the lower part of the vulva, the perineal body, the rectovaginal space and the levator ani muscles and fascia are infiltrated as for a spontaneous delivery. A plastic operation under local anesthesia is much simpler than one performed under a general anesthetic because the solution makes the lines of cleavage stand out prominently.

CESAREAN SECTION

For the classic cesarean section it is necessary only to infiltrate the abdominal wall. However for the transperitoneal cervical cesarean section in addition to this it is advisable to inject some solution beneath the bladder peritoneum. As I perform the low or cervical operation almost exclusively I employ a low midline abdominal incision for this operation and also for Porro cesarean sections. I begin by injecting a small amount of the procaine hydrochloride solution into the skin in the midline at a point which is to be the upper end of the proposed incision. For this purpose a fine needle is used in order to produce as little pain as possible. After the wheal is made a larger needle is substituted and is inserted into the opening made by the fine needle. Then procaine hydrochloride is injected into and under the skin all the way down to a point just above the symphysis pubis. The solution is injected not only in the midline but also for a distance of about 3 cm on each side of the midline all the

way to the pubis. As the latter area is extremely sensitive a good deal of procaine hydrochloride is injected there. The

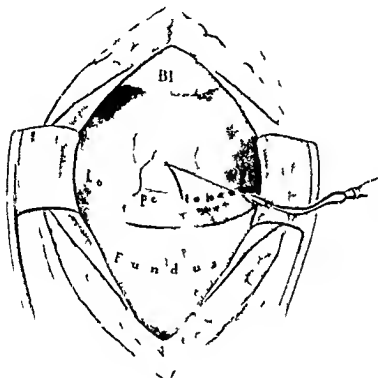


Fig. 28—Exposure of field for Pö o operation under infiltration anesthesia. The solution of procaine hydrochloride is injected at the spot beneath the peritoneum which is loosely attached to the lower uterine segment. A catheter is inserted into the bladder to prevent distention. (Greenhill J.A.M.A. 90 1023)

needle is kept in motion constantly to avoid introducing the solution into the blood vessels.

After a delay of four or five minutes to permit anesthetization of the skin and subcuticular fat an incision through the



Fig 29—With a finger the procaine hydrochloride solution under the loose peritoneum is gently pushed down under the bladder and well out into the broad ligaments upward and downward (Greenhill J.A.M.A. 90 1073)

skin and fat is made with a sharp knife. Then the anterior rectus fascia and the rectus muscles in the midline are de

sensitized but a new needle is used. Again more solution is injected into those parts of the fascia and muscle which are near the pubis.

After a few minutes of waiting the fascia is incised with a new knife and the rectus muscles are separated from each other in the midline. The posterior rectus fascia and the parietal peritoneum are then anesthetized for about 4 cm. on each side of the midline and a good deal of solution is injected over the bladder and into the space of Retzius. The peritoneal cavity is then opened. The reflection of the bladder peritoneum over the lower uterine segment is exposed and since this is only loosely connected with the uterine wall it can easily be elevated with tissue forceps. About $1\frac{1}{2}$ or 2 ounces (45 or 60 cc.) of procaine hydrochloride is injected under the loose peritoneum at one spot (Fig 28) and by means of a finger the solution is spread beneath the bladder and also out into the broad ligaments (Fig 29). It is essential to inject enough solution so that a sufficient amount can be squeezed into the broad ligaments outward upward and downward. No further anesthetization is required.

The bladder peritoneum is incised transversely the bladder is stripped down as far as one desires and a vertical (sometimes transverse) incision is made in the lower uterine segment. The baby is extracted manually or with forceps the placenta is removed and the uterus is closed. No additional anesthesia is necessary for the closure of the abdominal wall. Active labor is not a contraindication to local anesthesia but the labor pains will continue until the uterus has been emptied. In some of my cases I have been giving pentothal sodium intravenously for the few minutes while the baby is being delivered.

PORRO OPERATION

When a Porro operation is performed the bladder peritoneum is likewise cut across transversely and stripped downward but not very far and I believe that in nearly all cases the incision in the lower uterine segment should also be made transversely and not vertically. The transverse incision is

made in the lower uterine segment, but near its junction with the body of the uterus. The ends of the incision point upward in the direction of the round ligaments. The transverse incision in the lower uterine segment is preferable, first, because it avoids the necessity of stripping the bladder off the lower uterine segment very far, secondly because the amputation can be performed by simply continuing this transverse incision around to the posterior wall of the lower uterine segment and thirdly because there is no necessity for sewing up a vertical incision in the cervical stump in addition to a transverse circular one.

After the baby has been delivered, clamps are applied to approximate temporarily the cut edges of the uterus. The placenta, the cord and the membranes are left in the uterine cavity. The uterus is very gently lifted out of the abdominal cavity. More local anesthetic is injected into the broad ligaments and a small amount is injected subperitoneally on the posterior wall of the uterus along the line of amputation from one broad ligament to the other. The uterus is removed as in any hysterectomy.

STERILIZATION

For sterilization *when the abdomen is open*, as in a cesarean section the procedure is as follows. The tube and broad ligament of one side are exposed. If the procedure is to consist of resection of each uterine cornu about 5 cc. of solution is injected between the folds of the broad ligament just under the uterotubal junction. Since the tissue is thin and friable great care must be exercised to insert the needle between the thin folds of the broad ligament. Blood vessels must also be avoided. After waiting a few minutes the uterine end of the tube is gently elevated with an Allis forceps. A suture is placed around the tube about 1 inch from the uterus within the infiltrated area and the proximal portion of the tube is removed with a small wedge of uterine cornu. The uterine wound is sutured, the ligated end of the tube is buried between the folds of the broad ligament and the uterine corner

is covered with peritoneum. The same procedure is carried out on the opposite side.

A simpler method of sterilization is the *Madlener operation*. This consists of elevating the tube in its midportion, clamping it gently but firmly with a smooth clamp for about a minute and then tying a silk ligature in the groove formed by the clamp. This is a bloodless operation and when it is to be performed the local anesthetic is not injected at the uterotubal junction but within the broad ligament under the midportion of the tube.

If sterilization is to be performed *within twenty four hours after vaginal delivery*, an area is infiltrated in the midline just below the umbilicus as for cesarean section but much smaller and the foregoing sterilization procedure is carried out.

Sterilization *through the vagina* is usually done at the time a therapeutic abortion is performed. The method of producing anesthesia for dilatation and curettement is carried out as already described and after the curettement an additional 10 to 15 cc of local anesthetic solution should be injected into the space between the bladder and the uterus. The vaginal mucosa and peritoneum are incised just as for an interposition operation and the uterus should be brought down through the opening in the peritoneum into the vagina. With one finger the right broad ligament and its tube are exposed to view and about 10 cc of solution is injected within the folds of this broad ligament unless there is sufficient anesthetic in this region from the previous injection into the parametrium. Sterilization is carried out as already described for the abdominal operation. The same procedure is done on the left side. No further anesthetic is necessary for closure of the peritoneum or the vaginal mucosa.

PARASACRAL ANESTHESIA

Direct infiltration anesthesia does not inhibit uterine contractions; therefore it cannot be used for such operations as version, breech extraction and manual rotation of the head when it is high. For such cases parasacral or presacral anesthesia, another form of local anesthesia, may be used. The

technic described is that recommended by Tucker and Benaron who have used this form of local anesthesia extensively in the home

The necessary paraphernalia consist of 200 cc of a 0.5 per cent procaine solution to which 2 minims of 1:1000 adrenalin has been added for each ounce one 10 cc Lundy syringe one 23 gauge 3 cm Labat needle and two 20 gauge 15 cm Labat needles with guards 1 cm from the hub

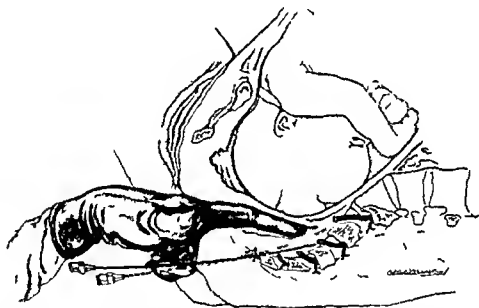


Fig 30—Antesacral (parasacral or presacral) anesthesia Desensitizing the sacral nerves as they issue from the anterior sacral foramina The engaged head is displaced upward lightly The needle is seen blocking the sacrococcygeal plexus (DeLee and Greenhill Principles and Practice of Obstetrics)

The patient is placed in an exaggerated lithotomy position and prepared for delivery The index finger of the left hand is placed in the rectum and the sacrococcygeal joint is palpated Then an intradermal wheal is made with the fine needle at the level of this joint from 1.5 to 2 cm on either side of the midline The 15 cm needle is grasped by the hub and inserted on the left side through the wheal at the level of the sacrococcygeal joint The point of the needle is advanced along the anterior aspect of the sacrum in contact with the

bone and parallel to the midline (Fig. 30). At 6 to 7 cm above the level of the sacrococcygeal articulation the second sacral foramen is encountered. If blood does not escape from the hub of the needle the syringe containing the local anesthetic is attached to the needle and the injection is started. As the needle is slowly withdrawn from 60 to 70 cc of solution is deposited between the second and the fifth foramina.

The needle is now withdrawn to the edge of the last sacral vertebra and its direction changed to a slight angle upward (15 degrees) so that it points toward the linea terminalis. It is advanced parallel to the midline. At a point 9 to 10 cm above the level of the sacrococcygeal articulation the first sacral foramen is encountered and 20 to 30 cc of solution is injected here. The needle is again almost withdrawn and the direction changed so that the point comes to lie over the coccyx. Ten cubic centimeters of solution is injected between the rectum and the coccyx thus blocking the sacrococcygeal plexus of nerves. The same procedure is repeated on the right side. About fifteen minutes is required to complete the injections.

Contraindications to parasacral anesthesia are (1) infection of the external genitalia, (2) intrapartum sepsis, (3) when it is imperative that the baby be delivered immediately and (4) in cases in which rupture of the uterus is threatened.

The *results* of parasacral anesthesia are excellent in most cases even when the head is deeply engaged. The uterine contractions cease during the infiltration and remain in abeyance for fifteen to twenty minutes. The soft parts of the pelvic floor remain relaxed for about two and a half hours. The tissues are so relaxed that the entire hand can be placed in the vagina without causing pain. Traction with forceps seldom produces discomfort. In some instances however it is necessary to complement parasacral anesthesia with local infiltration anesthesia to perform a painless episiotomy and repair.

The gynecologic operations previously listed can easily be performed by carrying out a technic similar to that outlined for the obstetric operations.

COMMENT

I hope that you and other physicians will take the time and trouble to investigate the subject of local infiltration anesthesia. You will quickly learn why those of us who employ local anesthesia extensively are so enthusiastic about it and you will also help to reduce the mortality and morbidity in obstetric and gynecologic patients.

GYNECOGRAPHY X RAY DIAGNOSIS IN GYNECOLOGY*

IRVING F STEIN MD FACS†

This morning I shall present a group of cases to illustrate the use of x ray for diagnosis in gynecology. You are familiar with the usual gynecologic examination which includes a thorough history and vaginal, recto vaginal, abdominal and specular examinations. A skilful bimanual and visual examination using good light often suffices for a routine diagnosis. There are many instances, however, in which such examination proves insufficient in providing the necessary data upon which to base an opinion. Unmarried girls in whom only recto abdominal examination may be made and rigid, neurotic and obese women—we have all seen them—make poor subjects for accurate gynecologic diagnosis by the usual methods. Then there are women complaining of abdominal pain in whom on bimanual examination no gross lesion can be found and other women who have sought opinions from a number of physicians, and received conflicting diagnoses. We must all admit that not a few patients who come to the gynecologist cannot be given a definite and positive diagnosis after the ordinary routine examination. Occasionally the diagnosis is not clarified even with examination under anesthesia or with the additional aid of biologic and clinical tests. It is in these various situations that x ray examination is indicated in order to avoid a faulty diagnosis and unnecessary surgery. This type of examination we have called gynecography.

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CASE REPORTS

The following case histories will illustrate the value of x-ray examination in selected cases

CASE 1—A S. aged twenty seven years married ten weeks consulted me in April 1930 because of inability to have intercourse. The menstrual history was normal beginning at sixteen years with the menses occurring regularly every twenty eight days lasting one week and moderate in amount. The last period had occurred on March 28 1930.

The patient was a short underdeveloped poorly nourished individual. Examination revealed that she had *practically no breast development* the left breast being completely aplastic a slight pimple like elevation representing the nipple. The right breast showed a very meager elevation with a similar nipple and both nipples were the seat of a few long coarse hairs. The external genitalia showed no gross abnormalities but on attempting digital examination a *double vagina* was found with two very small canals separated by a thick septum. Transillumination revealed that the septum was complete from the cervix to the vulva and two separate cervical oses were found. The intrapelvic organs were indefinite on palpation.

Gynecography was advised and in order to inject both cervical oses special cannulae were fitted to the self retaining patency set. An opaque medium (lipiodol) was injected into each cannula and a film (Fig 31 a) was taken. It was revealed that there were two separate cavities each of which led to a normal fallopian tube which was patent. Inasmuch as I could not determine from the film whether a single or double uterus was present or whether the ovaries were normal transabdominal pneumoperitoneum using 1 liter of carbon dioxide gas was then induced and a second film (Fig 31 b) was taken. The complete gynecographical film revealed that there was a *single septate uterus* which communicated with the double vagina by means of separate oses also that the ovaries were normal and both tubes were patent.

The following ten years gave rise to a number of interesting episodes in this patient's history. Shortly after the removal of the vaginal septum in May 1930 the patient became pregnant and carried her pregnancy to eight months. Because of sudden prolapse of the cord and a high breech presentation classical cesarean section was performed and a 5½ pound male child was

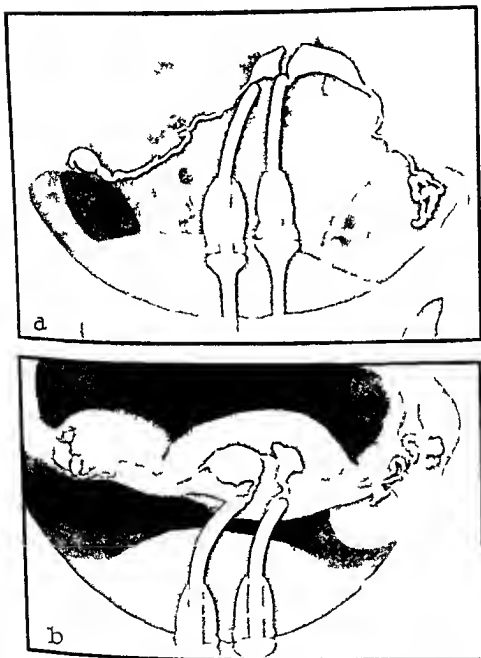


Fig 31—*a* Double vagina septate uterus patent fallopian tubes *b* Same case as preceding Single septate uterus and ovaries revealed by means of pneumoperitoneum Septate uterus shown by contrast medium

delivered The child was apparently normal except for a symmetrical finger deformity In February 1933 a second child a premature $3\frac{1}{4}$ pound infant that was apparently normal was delivered spontaneously

In August 1937 the patient again consulted me having been told that she had a carcinoma of the cervix. Examination revealed no evidence of neoplasm there being at the cervix the two ostia separated by scars from the excision of the vaginal septum. The uterus was slightly enlarged and irregular. Nevertheless the patient was operated upon by another surgeon who mistook her asymmetrical uterus for one containing a fibroid and decided that her irregular cervix was an indication for total hysterectomy. In performing the operation a ureter was severed leaving a ureterovaginal fistula because of persistence of the urinary fistula the kidney was subsequently removed. Postoperative examination of the specimen revealed a double ureter.

Thus in one patient a double vagina septate uterus double ureter and aplasia of the breasts were present. The family history gave evidence of an hereditary tendency to such genital abnormalities one of her sisters having had similar underdeveloped breasts and another required incision for an imperforate hymen.

In retrospect had the surgeon who had performed hysterectomy first made a gynecographic diagnosis he would have found as we had in the first instance that the seemingly abnormal uterus was a single septate uterus which contained no fibroid. Multiple surgical operations could have been avoided.

CASE II—M. C. aged thirty years had been married seven years. She had been desirous of pregnancy for the past one and one half years. Her menses had begun at age twelve occurred regularly at twenty nine or thirty day intervals and lasted four or five days they were moderate in amount no clots slight pain. The last period had occurred on June 28 1941.

On examination a 2 degree retroverted uterus was found but the adnexa were not palpable the cervix was clean no discharge being present. Endometrial biopsy performed on the first day of her period showed a secretory phase. The basal metabolic rate was minus 12.5 per cent. Sperm examination revealed the following amount 3 cc count 125 250 000 per cubic centimeter motility 80 per cent in two hours 50 per cent in five and one half hours there was a negligible number of abnormal forms and an occasional pus cell was present. The basal metabolic rate of the husband was minus 9 per cent.

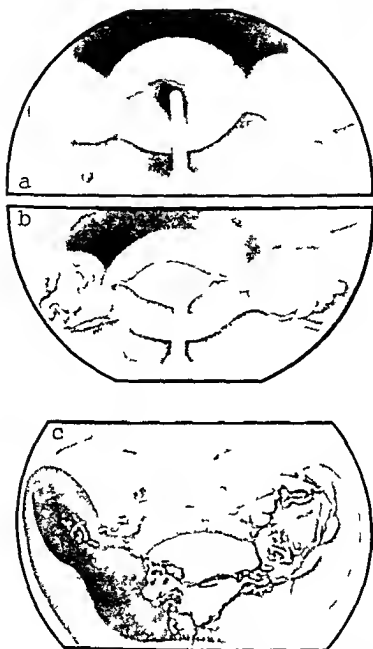


Fig 32—Transuterine pneumoperitoneum shows patent tubes normal pelvic viscera Gas outlines uterine cavity *b* Combined shows uterine cavity and tubes filled with contrast medium *c* Same as preceding case Profuse spill denotes both tubes patent

Because of indefinite findings on palpation complete pelvic gynecography was done instead of the simple routine patency test (Fig 32) Transuterine pneumoperitoneum was performed

followed by iodized oil instillation. The uterus as outlined by gas was normal in size and configuration; the ovarian shadows were normal. In the second film the uterine lumen showed a normal cast. The tubes filled and oil spilled into the peritoneal cavity from both sides in thirty minutes. The diagnosis was a normal genital status. On thyroid therapy the patient became pregnant within three months and delivered a healthy child at term.

CASE III—D. P., aged thirty years, had been married eight years and had one child aged six. Menses had begun at fourteen and were regular at twenty-six to twenty-eight day intervals.



Fig. 33.—Transuterine pneumoperitoneum in secondary sterility of four months duration. Intense dysmenorrhea. Pneumoperitoneum reveals numerous small fibroids.

there was a four day flow which was moderate in amount. Severe pain occurred one week before onset. The patient was referred to me by a general practitioner after she had consulted more than ten physicians because of her painful menstruation. There was a secondary sterility of four years duration. Numerous types of therapy had been tried without relief and radium had been suggested for her dysmenorrhea.

On examination a slightly enlarged uterus with two small fibroids in the anterior wall and some nabothian cysts of the cervix was found. The latter were cauterized with the actual cautery but this did not result in improvement; she still complained of the severe pain. A transuterine pneumoperitoneum re-

vealed that the fallopian tubes were patent that the uterus was symmetrically enlarged but irregular in outline with small typical nodules projecting from the surface. The uterine cavity which was outlined by gas was extremely small (Fig 33). From the pneumoroentgenogram it was seen that there were a large number of small nodules throughout the uterine body and it was evident that myometrial involvement was the cause of the intense dysmenorrhea. The pneumogram also revealed that myomectomy would be impractical. At laparotomy the findings were confirmed a great number of subserous and intramural fibroids up to 2 cm in diameter were found in the uterus. Supracervical hysterectomy was done and the patient made a complete and satisfactory recovery.

In this instance pneumoroentgenography was adequate for diagnostic purposes. The use of an opaque substance would have added nothing to the diagnosis except evidence that the uterine cavity was diminished in size, and this had been sufficiently demonstrated on the film by the gas in the uterine cavity.

CASE IV—S R aged twenty four years had been married two years. She complained of acute pain in the right side of the abdomen with nausea faint spells frequency of urination and diarrhea. The menstrual history was normal. On examination the pelvis was found to be extremely tender. The uterus seemed slightly enlarged and soft the cervix was soft and no adnexal swelling was palpable. History revealed the menses one week overdue but the patient declared that she was not pregnant since she had used contraceptive measures. Obviously the differential diagnosis rested between intra uterine pregnancy tubal pregnancy corpus luteum cyst ureteral colic and salpingitis. Biological pregnancy tests were inconclusive.

Transabdominal pneumoperitoneum was carried out and a roentgenogram obtained with the patient in the characteristic knee chest position. The films (Fig 34) revealed a symmetrically enlarged uterus with widening of the isthmic portion. Both tubes and ovaries were clearly shown to be within normal limits. The diagnosis was intra uterine pregnancy. On further interview and on informing the patient of the diagnosis she admitted that she had taken numerous oxytocic drugs in order to re establish her

menses. This fact previously withheld accounted for her pain and gastro intestinal disturbances.

In such cases I do not recommend transuterine diagnostic measures. carbon dioxide gas should be used for trans

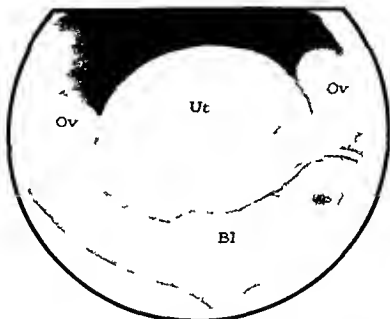


Fig 34—Trans abdominal palpation of an intra uterine pregnancy of six weeks

abdominal inflation since any uterine instrumentation might result in unintentional abortion.

CASE V—S. L. aged twenty one years single was referred to me by another physician. She had never menstruated she occasionally experienced breast fulness but without noticeable regularity. She had been given ovarian extract for six weeks by hypodermic without benefit.

Examination disclosed a tall well built girl who had large breasts with ample glandular development. There was scant genital hairy growth and absent axillary hair. The clitoris was of normal size and erectile. The left labium minora was hypertrophied and rugous the right was small and smooth. Some redness was visible about the Skene's glands. Smears showed epithe

lial cells and gram negative extracellular cocci. The vagina was extremely narrow just admitting the finger tip and ended bluntly about 2 inches above the introitus. Rectal examination revealed that neither the uterus nor adnexa were palpable.

Gynecography was advised to determine whether there was absence or deformity of the pelvic organs. Transabdominal pneumoperitoneum (Fig 35) revealed that no uterus or fallopian tubes were present. On each side of the pelvis was an ovoid structure interpreted as an undescended ovary. In the lower portion near the pubic symphysis the bladder could be plainly seen.

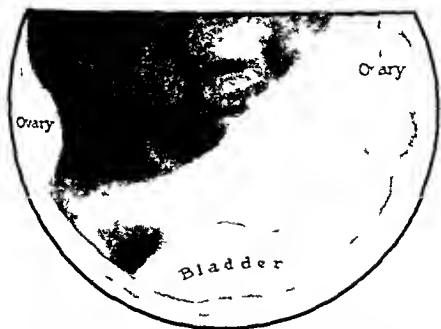


Fig 35—Transabdominal pneumoperitoneum shows complete absence of uterus and tubes and undescended ovaries.

I wrote to the referring physician advising that because of the congenital absence of both uterus and fallopian tubes neither surgery nor endocrine therapy was indicated.

In this instance it is quite evident that only the transabdominal method of examination is practical. With an absence of the uterus hysterosalpingography would be impossible whereas pneumoperitoneum is valuable in showing the absence of organs as well as the presence of normal or pathologic viscera. The findings of pneumoroentgenography in the presence of a normal uterus, fallopian tubes and ovaries (Fig

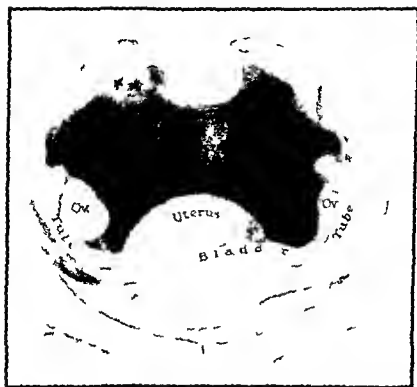


Fig. 36—Pneumoroentgenography. Normal uterus, ovaries and fallopian tubes.

36) are included for comparison with the preceding illustrations.

CASE VI—L. P. aged twenty one years and married two years was referred to me for sterility studies. Her menses had always been irregular with onset at thirteen years and no definite interval. There had been a one year amenorrhea from thirteen to fourteen years of age. The patient now spots continuously except for one week intervals between menses; occasionally she has had a profuse two day flow. She does not know the date of her last period since no regular cycle had been established. For some time there had been an intermittent sticking pain in the right lower abdominal quadrant. She had been told by her family physician that the uterus was tipped and had been given hypodermics several months previously.

Examination revealed markedly underdeveloped breasts with

practically no evidence of nipple or areola. Aside from fascial hirsutism there was a normal feminine distribution of hair on the body. The external genitalia were normal. The uterus was small and erect; both ovaries were markedly enlarged and tender. Endometrial biopsy demonstrated a proliferating phase. Trans abdominal pneumoperitoneum showed the uterine body to be about normal in size; both ovaries were seen to be greatly enlarged, each casting a shadow about the size of the uterine corpus. The diagnosis was bilateral polycystic ovaries.

At operation two weeks later the ovaries were found to be large, globular and smooth with thickened capsule. A typical ovarian wedge resection was performed. Examination one month later revealed that the patient had menstruated twenty-eight days after laparotomy; the first normal menstruation she had ever had. The breasts appeared to be definitely enlarged and the nipples showed considerable development. Three months later she reported that menstruation had occurred every twenty-one days lasting five days. The uterus and adnexa were normal to palpation. Follow up report obtained December 1, 1942, showed that menstruation had been normal and regular since operation. The patient became pregnant early in 1940 and spontaneously delivered a normal infant in June, 1941. Menstruation has continued normally since.

This case well illustrates the value of pneumoroentgenography in patients with amenorrhea or other menstrual disturbances. The pneumogram clearly revealed an ovarian enlargement and the necessity for surgical treatment. I might add that in a large series of patients with amenorrhea in whom gynecography has verified the diagnosis of bilateral polycystic ovaries, the cure of both the ovarian growth and the attendant sterility has been achieved by bilateral wedge resection.

GYNCOGRAPHY DEFINED

Gynecography is an inclusive term which embraces two separate x-ray procedures used by gynecologists for diagnosis. One of these is *pneumoroentgenography*, in which a gaseous medium is introduced into the peritoneal cavity for the purpose of separating the pelvic from the abdominal viscera. The gas provides a medium of contrast to the pelvic organs so that they may be visualized upon the roentgen film. The sec

ond method is *hysterosalpingography* in which a contrast medium such as iodized oil is used to fill the cavity and lumens of the uterus and fallopian tubes so that this so called cast can be demonstrated on the roentgen film

Of these two methods of examination that with the opaque medium reveals information concerning the interior of the uterus and fallopian tubes and pneumoperitoneum makes possible an examination of their contours the combination of the two together gives the maximum information concerning the pelvic status obtainable by means of x ray

INDICATIONS AND CONTRAINDICATIONS

Hysterosalpingography

Hysterosalpingography is chiefly of value when some abnormality in shape and development of the uterine cavity exists or when intra uterine growths are present. It also is a means of detecting obstruction of the fallopian tubes and may indicate the point of obstruction in one or both tubes. In normal fallopian tubes which are patent the contrast medium escapes into the abdomen from the free fimbriated ends of the oviducts and may be demonstrated on the roentgenogram as scattered irregular particles of opaque substance. When one or both tubes are closed and contain fluid as in hydrosalpinx iodized oil introduced into such tubes will form globules owing to the difference in the surface tension of the two liquids. The typical pearl brooch arrangement which we have previously demonstrated is characteristic of hydrosalpinx.¹ When the tube contains clotted blood as is found when an unoperated ectopic pregnancy results in a tubal mole the roentgen film will show the iodized oil broken up into numerous streams or channels where it penetrates the clots. It also will reveal a widely dilated tubal lumen but it rarely will surround the ovum and demonstrate it as such.

Mathieu claimed that in tubal pregnancy contrast medium will enter the tube as far as the first point of obstruction where it forms a round beadlike point which he described as pathognomonic of ectopic pregnancy. We have not observed this sign in our cases.² Some authors believe that with hysterosalpingography ovarian and uterine tumors will be outlined in

the peritoneal cavity by the oil surrounding them as it escapes into the peritoneal cavity. This has not been our experience. Submucous myomas and polyps, septate and double uteri, and the empty uterus in abdominal pregnancy are conditions which can be demonstrated by the use of radiopaque substances injected into the uterine cavity.

The following conditions *contraindicate* the transuterine route with either gas or iodized oil for the patency test, abdominal inflation or uterosalpingography: (1) pregnancy—apparent or suspected; (2) bleeding from the uterus; (3) purulent discharge from the cervix or vagina; (4) acute or subacute pelvic or abdominal inflammation; (5) pelvic tumor or mass completely filling the true pelvis or a swelling 3 inches or more in diameter.

Pneumoroentgenography

Pneumoroentgenography has a far greater field of usefulness for gynecological diagnosis, for by this means the normal uterus, tubes and ovaries can be clearly shown on the roentgen film. Often exploratory operation in cases of suspected pelvic lesions can be avoided by first obtaining such a film. In addition, any gross alteration in size, shape and density of these viscera, such as one observes in uterine myomas, ovarian cysts and tumors, tubal enlargements, and adhesions of the pelvic viscera to the omentum or to the intestines can be shown by pneumoroentgenography.

For the transabdominal route of inflation, the first three contraindications listed for hysterosalpingography (q.v.) are not operative, but the latter two hold for either method. In addition, the age and general condition of the patient must be considered. We have used transabdominal pneumoperitoneum in girls from thirteen to sixteen years of age with satisfactory results. On the other hand, we have avoided its use in elderly women, those with cardiac and pulmonary disease, and patients at any age who were debilitated.

While not directly contraindicated, pelvic visualization is not needed when the ordinary clinical means of diagnosis prove sufficient. However, in case of medicolegal issue, the preoperative roentgen evidence may be of great value.

HISTORICAL DEVELOPMENT

We have been asked by those not familiar with gynecography whether this is a new method. The answer is no. We have been using pelvic roentgenography for the past twenty years in the Gynecologic Service at Michael Reese Hospital and have examined more than 2000 patients by this method. Nor were we the originators of the procedure. We were however the first to combine the use of pneumoperitoneum and hysterosalpingography for complete gynecography, our first publication of this method appearing in 1926.⁴

Historically it is of interest that in 1902 Kelling⁵ injected air into the peritoneal cavity in order to visualize the abdominal viscera for endoscopy. More recently Ruddock⁶ and Hope⁷ revised this method of peritoneoscopy. Jacobaeus⁸ tried pneumoperitoneum first on cadavers and later upon 100 living subjects to determine whether the viscera might be injured by abdominal puncture. He encountered no instances of visceral injury or infection and but one case of bleeding. In 1913 he called attention in his monograph on abdominoscopy to the great advantage of combining pneumoperitoneum with a roentgen examination. This chiefly related to lesions of the upper abdomen and was confirmed by Orndoff⁹ who published his experience with this method in more than 100 cases (1919).

Alvarez¹⁰ first suggested the use of carbon dioxide gas for pneumoperitoneum in 1910 and used the Trendelenburg posture to visualize the uterus and ovaries on the roentgen film. It was not until 1921 however that Peterson and Van Zwaluwenberg demonstrated the practicability of pneumoroentgenography for gynecologic diagnosis. They adapted the Rubin patency technic to transuterine inflation and used the transabdominal puncture only in cases where tubes were obstructed or where the patency test was contraindicated. They also described the modified knee chest position for radiography in order to better visualize the pelvic viscera.

After an experience with 300 patients Peterson¹¹ reported to the American Gynecological Society his results. It certainly has been surprising to see how often it has been impossible to determine accurately by the examining finger the

exact condition of the pelvic organs. He said I failed to realize how much I was depending upon the opening of the abdomen to clear up the fine points in diagnosis. All this has been changed since roentgenography of the pelvis has been utilized as an aid to diagnosis. Yung¹ likewise stated that by this method a better differentiation between simple follicle cysts and ovarian tumors can be made and that conservatism in surgical treatment of myomas during the reproductive period may be clearly indicated by it. He pointed out the value of demonstrating normal pelvic findings to exclude pelvic adhesions, a diagnosis which leads to so many unnecessary operations. Stein and Arens¹² took up the method in 1922 and added a suitable radiographic table and a self retaining patency set to the armamentarium which greatly facilitated the technic. They also were first to publish the use of the combined method (1926) which they describe as complete gynecography.¹⁴

COMMENT

The technic for these procedures has been described adequately by us in previous publications¹⁵ where we have reported from time to time our growing experience with the method. After twenty years, our enthusiasm for its value in diagnosis has increased as we repeatedly encounter patients over whom difference in opinion has been satisfactorily settled by pelvic roentgenography rather than at the operating table. The method is not one to be used routinely, nor should it be utilized until the patient has had a careful history and the usual pelvic examination. But as in other fields of diagnosis gynecography takes its place as a valuable adjunct.

In our experience we have found pelvic roentgenography to be of inestimable value in the diagnosis of *sterility*, where perhaps we have used it most frequently. In such cases many physicians have been content to use hysterosalpingography alone but we have repeatedly demonstrated that significant lesions of the uterus and ovary particularly have been overlooked unless pelvic pneumoperitoneum has been used in addition. We are convinced that pneumoroentgenography is of diagnostic value in a far greater number of cases and it is unquestionably more accurate than hysterosalpingography.

This has been strikingly shown in the detection of ovarian lesions where by means of pneumoperitoneum the various ovarian conditions such as dermoids, lutein cysts and polycystic ovaries are commonly differentiated. Small multiple myomas of the uterus are rarely detected by the use of opaque media unless they are submucous but on the other hand may be clearly visualized by pneumoperitoneum when they are subserous or intramural—the more frequent locations.

In ectopic pregnancy as with intra uterine pregnancy we believe that all intra uterine methods should be avoided hence hysterosalpingography should not be used. With transabdominal pneumoperitoneum however we have diagnosed cases of unruptured tubal and of early uterine pregnancies in numerous instances when doubt previously existed. Complete gynecography in which both pneumoperitoneum and hysterosalpingography are used is indicated when either method used alone leaves the diagnosis incomplete.

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SURGERY OF DERANGEMENTS OF THE KNEE JOINT*

DANIEL H. LEVINTHAL, M.D., F.A.C.S.†

As the knee joint is the most complicated articulation in the human body and is subjected to the normal stresses of bearing the superincumbent weight of the individual plus the normal ranges of flexion and extension and the multiple traumas of abnormal axial rotation and medial and lateral forces it is not surprising that injuries, derangements and diseases are common in this region.

The conclusions reached in this clinic are based upon an experience with several thousand derangements of the knee joint in over 600 of which operation has been done. The statistical study to be presented later comprises an analysis of a large number of these cases made by my associate, Captain Irving Wolin, while still in civilian practice.

A resume of the anatomical features of any surgical problem is a *sine qua non* before attempting a study of the pathological picture and technique.

ANATOMY

The human knee joint is an extremely complicated articulation. The distal end of the femur articulates with the proximal end of the tibia. The posterior surface of the patella articulates with the anterior surface of the lower end of the femur. Each of these surfaces is covered by an *articular hyaline cartilage* (Figs. 38-39). In addition to the articular cartilages there are two crescentic fibrocartilages (*menisci*), one on each of the condylar surfaces of the tibia banking the joint similar to the elevations at the turn of a running track (Figs. 40-41). These *semilunar cartilages* deepen the tibial

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side of the joint cavities upon which the condyles of the femur roll. The horns of the semilunar cartilages are attached anteriorly and posteriorly to the tibial surface. The anterior horns are also attached to each other by the transverse ligament *ligamentum transversum*. Peripherally the semilunar cartilages are attached to the fibrous capsule of the joint. In

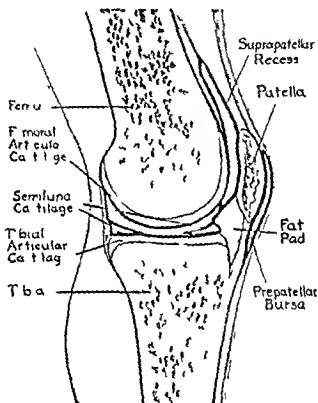


Fig. 38—Sagittal section through the knee joint showing relation of structures diagrammatically.

addition the *medial meniscus* is attached to the tibial (medial) collateral ligament.

The *synovial membrane* of the knee joint in addition to lining the joint surfaces has a reflection extending upward along the anterior surface of the femur and above the patella on the posterior surface of the quadriceps extensor tendon called the *suprapatellar pouch*. Within the knee joint are two

strong ligaments extending from the femur to the tibia and crossing in the intercondylar notch. These are called the

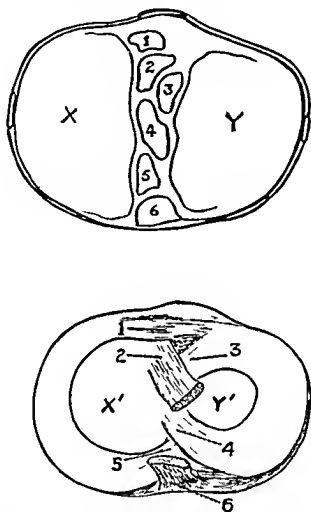


Fig 39—Superior surface of the tibia showing the points of attachment of the important structures 1 Anterior attachment of medial meniscus and ligamentum transversum 2 Anterior attachment of anterior cruciate ligament 3 Anterior attachment of lateral meniscus 4 Posterior attachment of lateral meniscus 5 Posterior attachment of medial meniscus 6 Posterior cruciate ligament

x Entire superior articular surface of the medial condyle of the tibia
y Entire superior articular surface of the lateral condyle of the tibia
x Area of contact of medial condyle of the femur y Area of contact of the lateral condyle of the femur

cruciate ligaments The anterior cruciate ligament is tight in extension while the posterior cruciate ligament is tight in

flexion of the knee joint. The *infrapatellar pad* is a fatty mass vertical section of which is irregularly pyramidal in form and fills up the interval between the patella femur and tibia in the anterior compartment of the joint. The *ligamentum mucosum* is a thin synovial fold extending from the infrapatellar fat pad to the anterior margin of the intercondylar fossa of the femur acting as a suspensory ligament. The *ligament of Wrisberg* is a strong fasciculus extending from the posterior portion of the lateral meniscus upward and inward to the medial condyle of the femur. A firm fibrous *capsule* surrounds

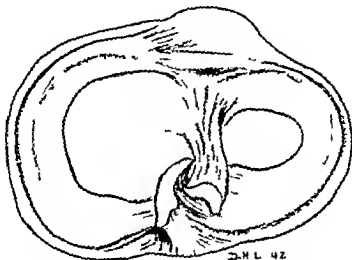


FIG. 40.—Relations of the menisci to the cruciate ligaments and the tibial condyles.

the knee joint. In addition to the capsule sometimes called the *capsular ligament* there are the *fibular* and *tibial collateral ligaments* sometimes called the *medial* and *lateral ligaments* the *ligamentum patellae* and the *oblique popliteal ligament*.

The knee joint is a hinge joint allowing extension to 180 degrees and flexion until the prominence of the calf comes in contact with the posterior aspect of the thigh. The range of flexion may vary with the age and activity of the individual. In flexion there is relaxation of the ligaments allowing a certain amount of axial rotation of the tibia on the femur.

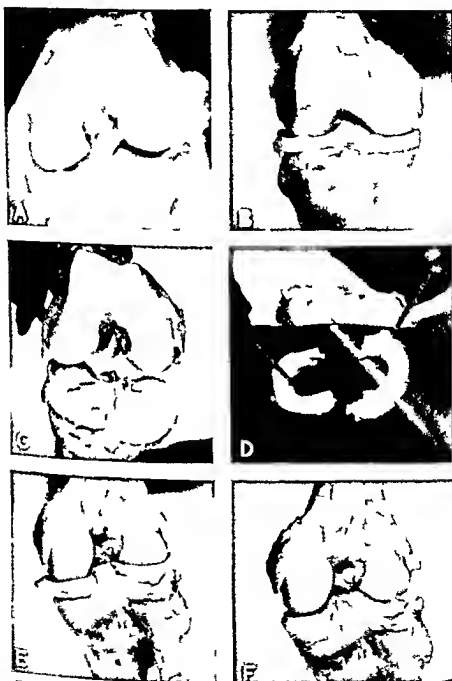


Fig 41—Dissected specimen A Anterior view of knee joint showing femoral condyles and anterior cruciate ligament B and C Relation of menisci to tibial and femoral condyles D The menisci E and F Posterior views

or when the tibia is fixed the femoral condyles rotate axially on the tibia

CLASSIFICATION OF DERANGEMENTS

Lesions of the knee joint are classified grossly into two main groups

- 1 Intra articular (internal) derangements
- 2 Extra articular

INTERNAL DERANGEMENTS

- 1 Lesion of the menisci (semilunar cartilages)
 - a Lacerations of the medial meniscus (internal semilunar cartilage)
 - b Lacerations of the lateral meniscus (external semilunar cartilage)
 - c Cysts and tumors of the menisci
 - d Calcification of the menisci
- Loose bodies
 - a Osteochondritis leucans (necrotic patellar epiphyseal area)
 - b Osteochondromatosis
 - c Osteoarthritic bodies
 - d Chip fractures
- 3 Lesions of the fat pad
 - a Detachment of patellar synovial fold (ligamentum mucosum)
 - b Hypertrophy
 - c Sclerosis
 - d Disuse
- 4 Injuries of the cruciate ligaments
- 5 Fractures
 - a Patella
 - b Lower end of the femur
 - c Upper end of the tibia
- 6 Arthritis
 - a Specific
 - (1) Tuberculous
 - (a) Knee joint proper
 - (b) Suprapatellar pouch (rarely separate from joint cavity)
 - (2) Gonorrheal
 - (a) Chondroosarcoma
 - (b) Capsular
 - (3) Pneumococcal
 - (4) Pyogenic
 - (5) Luetic
 - b Non specific
- 7 Synovitis
 - a Simple
 - b Traumatic
 - c Allergic
 - d Intermittent hydrops
- 8 Tumors
 - a Xanthoma
 - b Giant cell tumor
 - c Synovoma
 - d Sarcoma

EXTRA ARTICULAR DERANGEMENTS

- 1 Bursitis
 - a Prepatellar—housemaid's knee
 - (1) Simple sterile
 - (2) Purulent
 - (3) Tuberculous
 - b Popliteal medial and lateral
- 2 Epiphysitis of the tibial tubercle (Osgood Schlatter's disease)
- 3 Injuries to the medial and lateral ligaments sprains partial and complete tears
- 4 Ossifying epiperiosteal hematoma (Pellegrini Steda's disease)

GENERAL CONSIDERATIONS

From the above classification one can readily understand that it is sometimes difficult to make an accurate diagnosis of the type of derangement in each case. The exact diagnosis can usually be made by an accurately elicited history, a careful physical examination and roentgenograms taken antero posteriorly laterally and with bent knee of the normal as well as the affected knee joint. In the clinics of the writer, an accurate diagnosis of the particular type of lesion is attempted in each case. A generalized diagnosis of internal derangement is rarely made without mentioning the specific lesion. It is most important to differentiate those cases which may be treated conservatively from those which require arthrotomy. It is then imperative that one localize the lesion to the medial or lateral compartment of the knee joint by a very careful history and a complete physical examination of the part.

Internal derangements of the knee joint are to the orthopedic surgeon as the surgical belly is to the general surgeon. Rarely does a general surgeon today perform a laparotomy without a preliminary diagnosis. Likewise the qualified orthopedic surgeon rarely performs an exploratory arthrotomy without a preoperative diagnosis of the particular type of derangement.

Physicians in general practice are too frequently loathe to recommend operation on the knee joints and patients generally dread such operations because of the fear of later disability or ankylosis. *Under modern, aseptic orthopedic*

CLASSIFICATION OF DERANGEMENTS

Lesions of the knee joint are classified grossly into two main groups

- 1 Intra articular (internal) derangements
- 2 Extra articular

INTERNAL DERANGEMENTS

- 1 Lesions of the menisci (semilunar articular)
 - a Lacerations of the medial meniscus (internal semilunar cartilage)
 - b Laceration of the lateral meniscus (external semilunar cartilage)
 - c Cysts and tumors of the menisci
 - d Calcification of the menisci
- Loose bodies
 - a Osteochondritis leucaeans (including patellar chondromatosis)
 - b Osteochondromatosis
 - c Osteoarthritic bodies
 - d Chip fractures
- 3 Lesions of the fat pad
 - a Detachment of patellar synovial fold (ligamentum mucosum)
 - b Hypertrophy
 - c Sclerosis
 - d Disuse
- 4 Injuries of the cruciate ligament
- 5 Fractures
 - a Patella
 - b Lower end of the femur
 - c Upper end of the tibia
- 6 Arthritis
 - a Specific
 - (1) Tuberculous
 - (a) Knee joint proper
 - (b) Suprapatellar pouch (rarely separate from joint cavity)
 - (2) Gonorrheal
 - (a) Chondroosteoarthritis
 - (b) Capsular
 - (3) Pneumococcal
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 - (5) Lact
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 - d Intermittent hydrops
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 - d Sarcoma

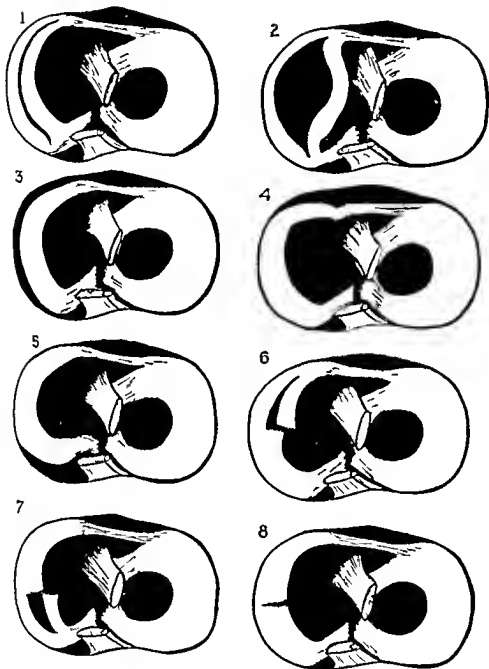


Fig 42—Common lesions of the internal semilunar cartilage 1 Longitudinal tear without displacement (bucket handle) 2 Longitudinal tear with displacement (bucket handle) 3 Complete marginal detachment (bucket handle) 4 Detachment of anterior horn 5 Detachment of posterior horn 6 Anterior flap laceration 7 Posterior flap laceration 8 Transverse tear

condylar notch the knee joint is locked or blocked This limits extension by 5 to 15 degrees, and when the examiner

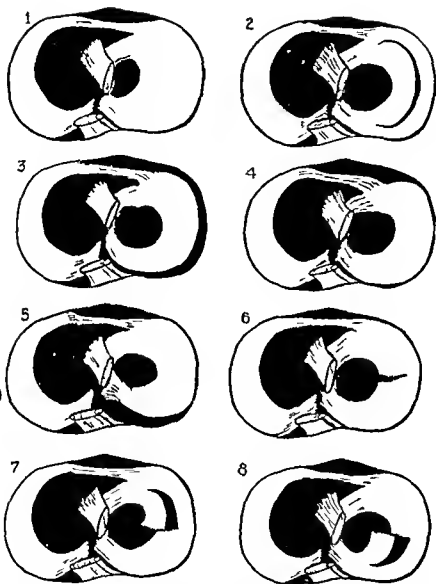


Fig. 43—Common lesions of the articular eminence and related structures. 1 Hyperthrophy (dislocation) of the articular eminence. 2 Longitudinal tear without displacement. 3 Complete marginal detachment (hypermobility). 4 Detachment of the anterior horn. 5 Detachment of the posterior horn. 6 Transverse tear. 7 Anterior flap laceration. 8 Posterior flap laceration.

tries to force extension pain is produced together with a rebound which we call the *spring reflex* of the blocked knee

This derangement does not limit flexion of the knee joint except when there is excessive fluid within the joint when there is usually more or less limitation in that direction. It is therefore apparent that *by locking we do not mean complete immobility*.

The spring reflex is present whenever the joint extension is blocked by other lesions, e.g. diseased or hypertrophied (nipped) fat pad or tears or cysts of the lateral meniscus, or when joint mice interfere with the mechanics of extension.

Tears or detachment of the posterior portions of the menisci cannot be readily visualized from the anterior approach. In these cases after the usual careful history, examination and diagnosis it has been our rule to remove the cartilage even though the inspection of the anterior compartment reveals no detachment or tear. As the anterior portion of the cartilage is detached and pulled forward with the cartilage grasping forceps the posterior tear or detachment is visualized.

Among the lesions of the menisci not illustrated in Figures 42 and 43 are calcification of the cartilages and cysts of the external semilunar cartilage. Cysts of the external meniscus may be within the cartilage body or between the cartilage and the capsule protruding laterally as a rubbery prominent mass.

In a few severe recurrent athletic injuries we have found both semilunar cartilages torn with associated tears of the anterior cruciate ligament.

Lesions of the Infrapatellar Fat Pad

The infrapatellar fat pad is frequently a cause of derangement. Hypertrophy (Hoffa) repeated nipping between the condyles and tears of the suspensory ligament (ligamentum mucosum) lead to sclerosis of the impinged margins and a vicious cycle ensues. In several instances we have made and confirmed this diagnosis at operation. Several times we have diagnosed a small bucket handle fragment or tear of the anterior horn, but upon opening the joint have found a pathological fat pad as described above. Resection of the offending portion of the fat pad and an anterior (ventral) suspension of the remainder of the fat pad to the anterior capsule has relieved



Fig. 44—Photograph of tissue removed from anterior compartment in synovectomy for hypertrophied fat pad

the patient of symptoms. Often the entire hypertrophied fat pad has been removed (Fig. 44).

Ossifying Epiperiosteal Hematoma

Ossifying epiperiosteal hematoma or *Pellegrini Stieda's disease* is usually due to trauma of the same type which in other locations produces a subperiosteal hematoma. In this particular region the writer found that the trauma causes a rupture of the periosteum just above or at the proximal attachment of the medial ligament of the knee joint at the internal condyle of the femur. The hematoma burrows its way between the deep muscle fascia and above the periosteum communicating with the cortex of the bone (Figs. 45-46). This hematoma becomes infiltrated with osteoblasts and later ossifies. The persistent pain is due to pressure under the underlying structures. In one case (Fig. 47) excision of this bony mass which resembled an artichoke leaf gave complete relief after every type of conservative treatment had been exhausted and after



Fig 45

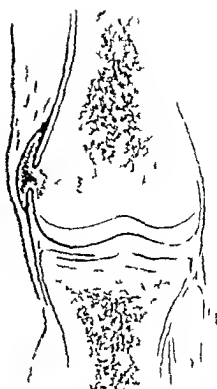


Fig 46

Figs 45-46 - Mechanism of formation of ossifying epiperiosteal hematoma



Fig 47 - Roentgenogram of ossifying epiperiosteal hematoma (Ollier's disease)

the patient had been treated for many months. This condition should not be confused with chip fractures of the medial condyle.

Loose Bodies

Osteochondritis dissecans of the knee joint is a condition of chondromalacia which involves the medial condyle of the femur adjacent to the intercondylar notch. Lying in a bed of degenerated softened fibrillated cartilage is a small fragment of cortical bone with an area of rarefaction above it. As the condition progresses this fragment of bone becomes extruded from its bed into the joint space. Early the symptoms of derangement are mild compared with other lesions. Later the symptoms become more severe as the fragment interferes with smooth joint mechanics.

The roentgenogram is diagnostic although in some instances the lesion involves the posterior portion of the medial condyle and may only be visualized in the special bent knee view.

Chondritis of the patella may be a simple degeneration of the articular surface or may be severe and include a loose fragment of the subchondral plate similar to that observed on the medial condyle. A special inferior superior bent knee roentgenogram to show the articular surface of the patella and femoral trochlea is valuable in this lesion. In making this exposure the patient rests prone upon the x-ray table, the leg acutely flexed on the thigh, the point of the patella over the center of the cassette.

At operation for osteochondritis dissecans or chondromalacia it is not sufficient to remove the actual or potential joint mouse, but it is imperative that the surrounding degenerated cartilage be carefully beveled with a sharp knife and the bed gently curetted down to normal smooth bone.

Osteochondromatosis of the knee joint consists of one or more often many osteocartilaginous bodies (Fig. 48). These are usually synovial in origin and some of them may be found attached to the synovial membrane. In those cases with multiple joint mice it is wise after removing those which can be visualized to don a fresh glove over the one which is worn.

and insert the index finger into the suprapatella pouch and the lateral compartment to search for hidden mice. It is also good judgment to milk the popliteal space by external manual compression.



Fig. 48—Typical joint mice (osteochondromatosis)

Other sources of loose bodies in the knee joint are detachment of brittle osteoarthritic margins and loose fragments from fractures of the articular surfaces.

Injuries of the Cruciate Ligaments

Tears of the cruciate ligaments usually cause increased anteroposterior movement of the tibia on the femur and considerable disability. However, there are cases on record of complete dislocation of the knee joint in which, of course the cruciate ligaments have been completely torn, with nearly normal function after conservative treatment.

The anterior cruciate ligament is more frequently torn or attenuated than the posterior. Frequently it is associated with a tear of the medial meniscus and the medial collateral ligament. This type of injury requires repair of both the medial

and cruciate ligaments and excision of the torn meniscus. The operative procedures are numerous and comparatively formidable and include the utilization of a band of fascia lata.

Patients with strong medial and lateral ligaments and good quadriceps extensors may follow ordinary pursuits without repair of a torn anterior cruciate ligament. However, this weakened knee is inadequate for major sports and usually causes some difficulty in descending stairs.

Injuries of the Collateral Ligaments

Tears of the medial or lateral ligaments of the knee joint must be immediately recognized. Roentgenograms must be made to differentiate between a simple tear and a sprain fracture or osteoperiosteal detachment. The latter requires a longer period of immobilization. The simple tear requires immobilization in a snug fitting plaster cast with knee joint flexed about 5 degrees. After one week the cast should be bivalved for physical therapy consisting of heat, light massage and quadriceps setting exercises.

Severe or old unrecognized tears of the medial or lateral ligaments of the knee joint require operative repair. In injuries to the medial ligament requiring surgery, the distal 8 cm. of the gracilis tendon may be utilized. The free proximal end is securely attached to the medial condyle of the femur. The loose distal end of the severed gracilis tendon is attached to the semitendinosus tendon. The lateral ligament may be repaired by a fascia lata transplant.

Inflammatory Diseases

Synovitis of the knee joint of traumatic origin is treated by early careful aspiration followed by the application of a firm compression bandage and rest. Chronic synovitis or the recurrent synovitis known as intermittent hydrarthrosis may be best treated by synovectomy (Fig. 44).

Popliteal bursitis, a fluctuant, tense swelling in the popliteal space, may be medial or lateral. The medial arises from the medial gastrocnemius head and the semimembranosus tendon and may assume large proportions (5 by 10 cm.) and cause

considerable disability. This sac usually does not communicate with the joint.

Posterior herniation of the knee joint synovial membrane so called *Baker's cyst*, also produces a popliteal bulge. These sacs must be carefully excised.

Prepatellar bursitis, or housemaid's knee may be treated by simple aspiration and compression or, if recurrent or chronic may require either the injection of dilute iodine (Pregl's solution) or scarification with a tenotome followed by compression. When the lining is palpably thick and there are rice bodies the treatment of choice is excision. The excised tissue in chronic cases should be examined microscopically and it



FIG. 49—Prepatellar bursitis (This case proved to be tuberculous)

times it is judicious to inject a guinea pig. The case shown in Figure 49 was tuberculous.

Localized fluctuant swelling of the suprapatellar pouch which does not respond to aspiration immobilization and other usual conservative measures requires excision. In one of our cases (J.H. Cook County Hospital) operation was performed after months of vain conservative treatment. Complete excision of the pouch which was firmly encapsulated and separate from the knee joint proper proved the lesion to be tuberculous. The patient made an uneventful recovery with complete restoration of function.

Another patient with true derangement resulting from in



Fig 50—Epiphysitis of the tibial tubercle (Osgood Schlatter disease)



Fig 51—Roentgenogram of epiphysitis of tibial tubercle (Osgood Schlatter disease)

jury had an arthrotomy of the knee joint for removal of the torn medial meniscus. At operation it was noted that the infrapatellar fat pad was hypertrophied, irregular and of pathological color and consistency. After removal of the torn meniscus the entire fat pad including its alveoli was removed. Sections and guinea pig inoculation proved the diagnosis of *tuberculosis*. This was evidently a very early primary synovial tuberculosis. The patient made a slow convalescence but regained over 90 degrees range of smooth painless motion.

Epiphysitis of the tibial tubercle (Osgood Schlatter's disease) is frequently misdiagnosed. It occurs in children nine to fourteen years of age most frequently in boys (Figs 50, 51). They complain of limited flexion, pain, tenderness and localized swelling over the tibial tubercle. The roentgenograms show fragmentation of the epiphyseal beak. Occasionally there is local heat suggesting infection. The treatment consists of immobilization preferably in a plaster cast for from four to eight weeks permitting weight bearing or a firm long adhesive strapping limiting flexion of the knee. Old neglected cases with prolonged pain on flexion and nonunion of the tibial tubercle interfering with function of the patellar tendon require simple excision of the loose fragment.

Tumors of the Knee Joint

Tumors of the knee joint (4 per cent in our series) may be intra articular or extra articular.

Xanthomatous giant cell tumors of the synovial membrane (Fig 52) were found in four of our cases. Complete anterior chamber synovectomy was performed followed by deep irradiation. In one case there was recurrence, reoperation and no recurrence in five years.

Giant cell tumor of the lower end of the femur or upper end of the tibia frequently causes symptoms resembling internal derangement plus arthritis. Our technic consists of thorough resection of the tumor, curettage, aspiration with wide tube suction apparatus, endothermy followed by more curettage and lavage and suction. Then long bone graft struts are placed within the cavity and multiple spongy bone chips are packed between the struts and a plaster spica cast is applied.

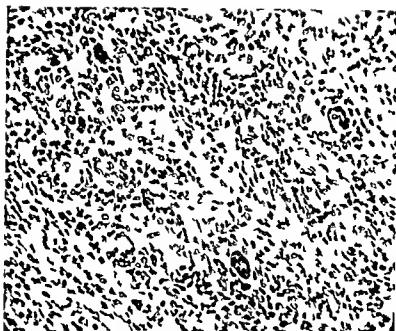


Fig. 52—Photomicrograph of a histological section of a spindle cell tumor of the knee joint. Hematoxylin-eosin preparation $\times 160$. Note the many spindle-shaped tumor cells and the multinucleated giant cell. Because of the marked cellularity and the occasional mitotic figure it was thought that the tumor would recur.



Fig. 53



Fig. 54

Figs. 53-54—Show range of motion after Putti-Platt therapy

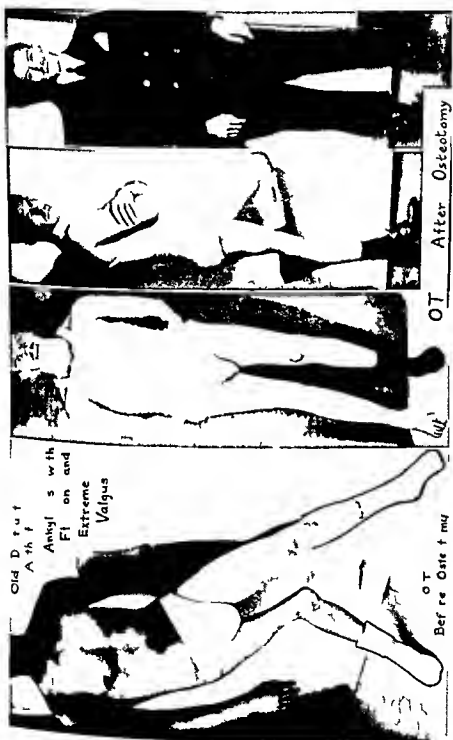


Fig 55--Before and after osteotomy to correct ankylosis in valgus

OPERATIVE TECHNIC

The majority of the operative procedures in these clinics have been standardized using the Krida utility incision (Fig 56). A pneumatic tourniquet is inflated after the limb has been elevated during the preoperative preparation. For the simpler cases a short incision (2 inches) is made parallel to the medial border of the patella and the patellar tendon. The knee is flexed at right angles. The skin is meticulously walled off with lap pads and skin clips. Special blunt retractors are used



Fig. 56—Utility incision (Krida) anteromedial approach to the knee joint

to avoid injury to the articular surfaces. The joint is inspected with a simple blunt hook. For visualization of the inferior surface of the patella and the pouch, the knee is extended and the extensor apparatus retracted. With proper light and retraction, the lateral anterior chamber may also be visualized. In removal of the meniscus the Martin cartilage grasping toothed forceps and the special curved Freiberg knife facilitate resection of the cartilage.

Before closure the joint must be carefully inspected for as

sociated pathologic involvement After routine closure a generous compression dressing is applied Then the tourniquet is removed

Immediately after operation the patient is taught to contract his quadriceps muscles and on the second day after simple meniscectomy is urged to attempt weight bearing without crutches

I would like to discuss the various fractures which contribute to derangement of the knee joint and to spend some time on the subject of arthritis specific and nonspecific, but the subjects are too broad to be included in this clinic

THE TREATMENT OF COMPOUND FRACTURES IN THE WAR INJURED*

EDWARD L. COMPERE MD FACS†

TODAY, in the midst of a global war, it is well to review our methods of treatment of compound fractures and to see how far we have advanced since 1918. A compound fracture is just as much of a surgical emergency as is an acute appendicitis or a perforated peptic ulcer. Delay in treatment may be disastrous. Two primary considerations must be kept in mind in planning the management of patients who have suffered compound fractures. The first is *prevention or treatment of shock* and the immediate preservation of life. The second, of almost equal importance, is the *prevention of infection* in the wound.

Long before the discovery of the sulfonamide drugs there were a few courageous surgeons in America who taught and practiced what we now consider to be the ideal in compound fracture management. About fourteen years ago Dr. Dean Lewis, who had left Chicago and my own alma mater, Rush Medical College, to go to Baltimore as Professor of Surgery at Johns Hopkins Medical School, delivered a lecture on fractures at the University of Chicago. One of the first statements of his address was approximately as follows:

'The competent surgeon who possesses the discipline, the surgical technique, the skill and the courage to do so can turn most compound fractures into simple fractures.'

He emphasized what a few surgeons had already learned that some contaminated wounds could be excised and infection prevented by what we have known as *debridement*. Debridement does not signify the mere cutting away of skin.

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fracture are that this method, when successful, turns compound into simple fractures both primary and secondary infection is avoided and osteomyelitis is prevented healing of soft tissues is complete in ten to twelve days the scar is linear and nonadherent, it decreases hospitalization and the period of disability is decreased

In a comparatively few cases the fractures may be so severely contaminated that it is not possible to obtain adequate cleansing and thus change a potential infection into a clean wound These cases may be treated by packing with vaseline gauze and immobilization in plaster cast after the Orr method

DELAYED TREATMENT

When a fracture is seen for the first time after infection is definitely established or too long after injury to permit of primary closure of the wound the method of treatment is somewhat different The following plan has proved adequate in my hands

- 1 Regional or general anesthesia
- 2 Continuous skeletal fixation
- 3 Adequate drainage of pus opening every recess and removing grossly necrotic tissue
- 4 Removal of sequestra and foreign bodies
- 5 Pack wound using sulfanilamide impregnated vaseline paraffin or aquaphor
- 6 Plaster of paris splinting
- 7 Sulfathiazole or sulfadiazine (4 gm immediately and 1 gm every four hours thereafter) by mouth

The present war with its bombing of the civilian population as well as of men in the armed forces brings other problems in the treatment of compound fractures

We now know that in modern warfare *between 50 and 80 per cent of all major casualties* include at least one compound fracture It may not be possible until days have elapsed to render more than first aid treatment to the large number who may be seriously injured during a battle or a bombing raid upon one of our cities

In the Pearl Harbor catastrophe casualties were brought as rapidly as possible to all of the available hospitals of Hono

lulu and to other emergency shelters. In most instances compound fractures and other extremity injuries were given only the most superficial attention. Abdominal and chest wounds and wounds to the head and brain were treated first. The attendants and nurses were instructed to place large amounts of sulfanilamide in the compound fractures and other wounds of the extremities and to apply over that a sterile dressing. Many of these wounds did not receive the attention of the surgeon for three days after they were inflicted. The services of many different doctors were utilized in the treatment of these injuries. Some men were called upon to treat fractures who had had too little training and experience to be qualified to do this type of work. Some of the wounds were closed after cleansing and debriding and others were packed open with vaseline gauze. According to Abbott¹ debridement was not properly done in all of the cases yet there was no serious infection in the series. There were about six cases of well localized osteomyelitis.

OUTLINE OF TREATMENT

The following outline of treatment is applicable to the care of compound fractures resulting from war injuries if there are available competent surgeons with adequate facilities to give it.

Emergency Care

- 1 Give $\frac{1}{4}$ grain morphine sulfate *unless there is a head injury*
- 2 Pack wound with sulfanilamide
- 3 Cover with sterile pressure dressing
- 4 Apply emergency splinting
- 5 Transport patient to hospital without unnecessary delay
- 6 Clamp severed blood vessels
- 7 A tourniquet is dangerous. It may be overlooked and gangrene result.

Hospital Care

- 1 Treat shock (Warm blankets, plasma, whole blood or glucose and saline)
- 2 Excision of wound in operating room
 - (a) Place leg in traction on fracture table

- (b) Obtain roentgenograms
- (c) Apply skeletal traction if indicated
- (d) Scrub skin ten minutes with white soap and sterile gauze (use benzine or ether and iodine on the skin but not in the wound, if scrubbing is not feasible)
- (e) Wash interior of wound five minutes using white soap and water, irrigate with large volumes of warm, sterile physiologic salt solution
- (f) Excise walls of wound, starting from skin and go downwards and obtain hemostasis
- (g) Remove all infected bone
- (h) Remove only completely detached fragments
- (i) Reduce fracture
- (j) Pack wound with sulfanilamide
- (k) Close wound without tension if patient is seen within six to eight hours. Make parallel skin incisions at a distance from the wound to effect closure if necessary
- (l) Pack wound open with sulfanilamide vaseline impregnated gauze if patient is seen after eight hours or if in the opinion of the surgeon the wound should not be closed even if excision of wound is completed before eight hours have elapsed since injury. If there are multiple wounds (bomb fragments) or the surgeon is not experienced in compound fracture surgery this open pack method should be compulsory
- (m) Immobilize fracture enabling patient to be ambulatory on crutches if at all possible (Roger Anderson pins or metal plates are recommended where skeletal fixation is indicated)
- (n) Give tetanus antitoxin
- (o) If wound is contaminated with material from the highway or field give gas bacillus antitoxin
- (p) Sulfathiazole or sulfadiazine should be administered in full doses by mouth

Abbott studied the result of treatment of seventy two compound fractures in sixty three patients who were wounded at

Pearl Harbor There were six infected wounds with localized osteomyelitis The remaining wounds were healing by granulation tissue and Abbott was of the opinion that compound fractures incurred under war conditions may be most safely treated by the sulfonamides and open pack method With this opinion Wilson after more than a year of observing treatment of war wounded in England, is in agreement Healing is delayed and osteomyelitis is more common than when the primary closure technic is properly carried out But with every available physician pressed into service following a mass catastrophe the incidence of sepsis and deaths would undoubtedly be higher if primary closure were substituted for the open pack method

While we hope that the physicians left at home to care for the civilian population may never be called upon to treat compound fractures resulting from bombing raids it is well for each one to review his knowledge of the treatment of compound fractures and to familiarize himself with the more modern methods of treatment

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SUBTROCHANTERIC OSTEOTOMY FOR FRESH FRACTURE OF THE NECK OF THE FEMUR*

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THE prognosis following intracapsular fracture of the femoral neck is still questionable regardless of the method of treatment followed. This was shown in the 1941 committee report of the American Academy of Orthopedic Surgeons.

ETIOLOGY

The most important casual factor is direct force. The patient usually gives a history of having slipped and fallen from a standing position striking the posterior aspect of the greater trochanter which in these elderly patients is devoid of much flesh. Force is exerted in a forward direction so that the strain comes directly on the weak fragile portion of the neck. The proximal portion or head is held securely in the acetabulum the point of greatest strain occurs anywhere between the head and the trochanter and fracture occurs at that point namely the point of least mechanical advantage by a rotatory thrust forward of the greater trochanter and upper portion of the shaft on the acetabular portion.

PATHOLOGY

Accuracy of reduction of the fracture is no guarantee that solid bony union will follow. Possibly the slight movement allowed with any but internal fixation methods is one of the major causes of absorption of the cancellous bone of the neck. Internal fixation affords good and sound immobilization and is a most important factor facilitating osseous union. I believe

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that a disturbance or interruption of the circulation is less likely to be the cause of absorption of the neck per se than what has been accepted as a physiological process namely an uninterrupted early rarefaction of the fracture surfaces. As Murray has so well shown the hydrogen ion concentration in the fracture site is on the acid side for the first ten to twelve days shortly thereafter the concentration changes to the alkaline side and favors fixation of calcium in the provisional callus. Although aspiration of the intracapsular fluid has not been done to establish proof in any of these cases it seems altogether possible that there being an abundance of synovial fluid present to dilute the exudate from the fractured surfaces the hydrogen ion concentration does not reach a stage favorable for the deposition or fixation of calcium that obtains in uncomplicated simple fractures. In fact the usual early absorption of calcium from the fractured bone ends continues uninterrupted until the cancellous bone of the neck is more or less completely absorbed. When nonunion occurs the usual end result is complete absorption of the neck.

The *diagnosis* in all cases is confirmed by x ray before during and after treatment.

TREATMENT

I am convinced that the great majority of intracapsular fractures can be reduced by the Leadbetter¹ method regardless of the obliquity of the fracture or the so-called spur on the proximal or distal fragment as has been emphasized by Ettore and regardless of the displacement present. This was proved at autopsy in several cases of recent fracture.

In old unfavorable cases of nonunion some of the more enterprising and aggressive of the earlier orthopedic surgeons designed operative procedures of an ingenious nature which are mechanically sound in principle and which overcome the extreme disability. Notable among these were Lorenz² and Schanz.⁴ Their aim was for improvement in stability. McMurray⁵ of Liverpool has modified the methods of these two surgeons and places the site of the osteotomy just below the line of the lower level of the acetabulum. In the foregoing procedures the main principle which is mechanically sound is a

change in the direction of the axis of the shaft of the femur. The shearing stress is eliminated and in its place is substituted direct axial impacting pressure of the lower fragment against the head or what remains of the head in the acetabulum. Whether this principle is accomplished by angulation so that the upper end of the lower fragment points to the middle of the acetabulum as a center or whether it is fulfilled by a shift of the upper end of the lower fragment inwards so as to make the weight bearing line of the body through the pelvis and the acetabulum extend down in a direct line through the shaft of the femur without so much angulation, improved stability is the result. In my opinion this fully justifies the operative procedures under discussion which at most are mild surgical measures compared to the reconstruction and pegging operation that entail much more hazard and much more shock to the already debilitated individuals.

The nailing and pinning operations are distinct therapeutic advances because the fragments can be firmly and securely held in position, so that there is needed only a minimum of external apparatus for immobilization. However to accomplish proper alignment of fragments and proper placement of nails or pins, a high degree of technical skill, cooperative teamwork and the assistance of well trained personnel are an absolute necessity. Without these, success is doubtful from the beginning. I prefer the cannulated Smith Petersen⁶ nail, which after closed reduction is inserted through a small incision below the greater trochanter.

In the smaller hospitals however, it has been found difficult to meet all the detailed requirements which are so necessary for an extensive operative procedure like internal fixation or for operations of a reconstructive nature. The usual decision then has been to follow the simplest and least shocking method of treatment with results that generally are poor. In an effort to forestall this calamity and to give the patient a more helpful prognosis a simple procedure was sought.

In old ununited fracture good results have followed transverse subtrochanteric osteotomy not only in my own cases but in many larger series of other surgeons. It was subsequently suggested that the osteotomy could be done in the

aged then walking with crutches is allowed. The use of a cane is usually necessary for several months. Shortening which averages between $\frac{1}{4}$ and $\frac{3}{4}$ inch is overcome by a suitable lift on the heel.

CASE REPORTS

CASE I—Miss M. M. aged sixty years sustained a fracture of the femoral neck. X rays (Fig. 58 A) showed an oblique fracture

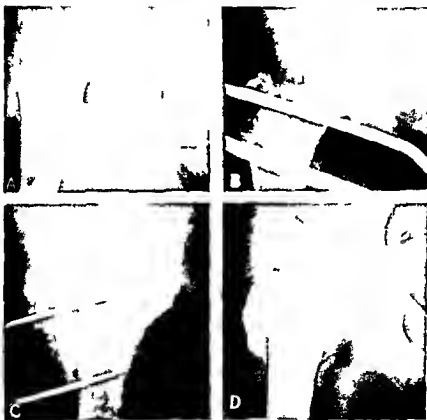


Fig. 58 (Case I) —A Oblique fracture of neck of right femur with spur on upper and inner side of lower fragment. B Twelve days after the application of traction. C Steel pins above and below osteotomy for control of fragments. D Eleven weeks after subtrochanteric osteotomy. There is considerable callus formation with firm union, but the lower fragment has not been sufficiently displaced inward.

through the neck of the right femur with a spur on the upper and inner side of the lower fragment. Traction was applied for



Fig 59 (Case II) —A Fracture of the femoral neck B C Five months after subtrochanteric osteotomy There is good union between the displaced upper end of the shaft the trochanter and the head

twelve days (Fig 58 B) Thirteen days after the injury operation was performed according to the method described Before osteotomy steel pins were inserted above and below the proposed osteotomy site for better control of the fragments (Fig 58 C) The postoperative course was uneventful At eleven weeks the cast was removed and apparently union was firm A new x ray view at this time showed considerable callus formation (Fig 58 D) but also revealed that the lower fragment had not been sufficiently displaced inward The patient required crutches for five months but now has fairly free movement and walks with the aid of a cane

CASE II—Mrs E P aged seventy two years sustained a fracture of the left hip X rays (Fig 59 A) showed a fracture of the neck Traction was maintained for two days when a subtrochanteric osteotomy was performed Postoperative x ray views showed the shaft displaced well under the head The cast was removed at twelve weeks There was good stability and shortening of $\frac{1}{4}$ inch The x ray two months later showed good union between the displaced upper end of the shaft the trochanter and the head (Fig 59 B C) The patient was allowed up shortly thereafter and later walked without pain with firm and sure step and with a slight limp Shortening was $\frac{1}{4}$ inch

CASE III—Mrs M D aged fifty one years sustained a transcervical fracture of the right hip as revealed by x rays (Fig 60 A) Traction was applied and maintained for five days at which time the length was normal (Fig 60 B) Subtrochanteric osteotomy as described was performed six days after the accident The postoperative course was mildly stormy X rays (Fig 60 C) show the oblique osteotomy with moderate displacement of the shaft medially On the nineteenth postoperative day and the twenty fourth postfracture day there was a sudden onset of pallor pain in the chest and abdomen followed by cyanosis Forty minutes after the onset of the attack the patient expired The autopsy revealed bilateral emboli in the main and secondary pulmonary arteries and recent red thrombi in the left external and internal iliac veins (fracture was in the right hip)

CASE IV—Mrs M K aged fifty eight years sustained a fracture of the left hip X ray showed a transverse fracture through the middle portion of the neck Traction was applied for two

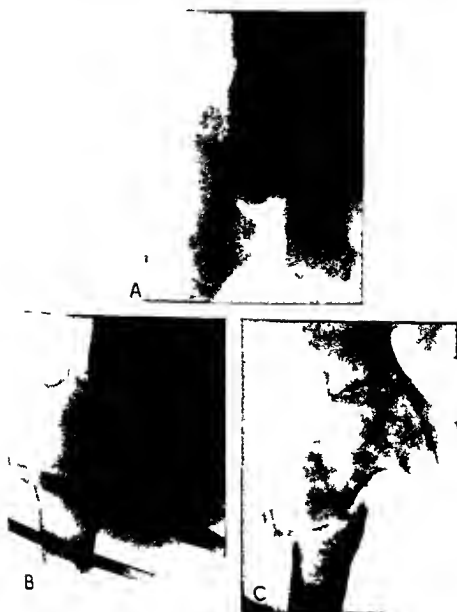


Fig 60 (Case III) —A Transcervical fracture of the right hip B After five days of traction C Results of oblique osteotomy with moderate displacement of the shaft inward

days at which time shortening was overcome. An operation was performed according to the method described and a cast applied. Immobilization was continued for twelve weeks. When the cast was removed there was good stability. Crutches were used for twelve weeks after which the patient walked with only a slight limp.

I have performed the operation of subtrochanteric osteotomy in six additional cases during the past two years. In all cases the union is stable and the patient walks with only a slight limp. None has more than mild arthritic pain. In these cases shortening averages between $\frac{3}{4}$ and $\frac{3}{4}$ inch.

SUMMARY AND CONCLUSIONS

1 The results of conservative treatment of intracapsular fracture of the femoral neck are poor: nonunion occurring in an average of 54 per cent and death in an average of 12 per cent of cases.

2 In view of these poor results it is my opinion that a more radical form of treatment is often desirable. When facilities for pinning are not available I prefer the moderately radical operation of subtrochanteric osteotomy in selected cases.

3 This operation has been employed in a series of ten cases of recent fracture. One patient died from a postoperative pulmonary embolism. The end results in the other cases have been uniformly favorable, with good firm union and only a slight shortening.

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CARCINOMA OF THE RECTUM

RICHARD K GILCHRIST M D

CARCINOMA of the rectum has a more favorable prognosis than carcinoma in any other part of the gastro intestinal tract. This is in part due to the fact that patients so afflicted have bleeding which brings them to the doctor early. Yet in spite of the fact that most of these tumors can be palpated at rectal examination it is still true that about a third of all patients presenting themselves in clinics for the treatment of carcinoma of the rectum are beyond hope of cure.

SYMPTOMS

The most constant symptom in carcinoma of the rectum is a *change in bowel habits*. This may take several forms. A patient who has previously been regular begins to have two or three movements a day instead of the usual one, or he begins to have alternating periods of mild constipation followed by several days of diarrhea. The shape of the stool is often changed if the lesion is low. The stool often resembles a tooth paste ribbon.

The *passage of blood* or blood and mucus is a common but not constant symptom. The blood is usually on the surface of the formed stool if the lesion is in the rectum or lower sigmoid and is red or dark red in color. The stool may be streaked with blood mixed with mucus in which case one must be careful not to miss the diagnosis. When the lesion has grown larger the patient when he goes to stool will often simply pass a small amount of blood and mucus with little or no feces.

Another common complaint is sacral or low *backache*. This is apt to be simply a feeling of heaviness or pressure and is

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often relieved by bowel movement Pain is not an early symptom in carcinoma In fact when pain makes its appearance the lesion has usually become attached to some other structure or an abscess has formed around it

DIFFERENTIAL DIAGNOSIS

Most laymen and many doctors jump to the conclusion when a patient passes blood that *hemorrhoids* are present Hemorrhoids are varicose veins and generally cause no more symptoms when found around the rectum than do varicose veins in the leg unless something happens to them When they are torn or fissured there may be blood in the stool and smarting or burning pain If this fissure becomes infected a small abscess develops which causes throbbing pain If the veins are thrombosed a tender swelling is present The blood from a hemorrhoidal vein is red in color it is on the outside of the stool and it usually comes at the very end of the bowel movement The bleeding may be quite profuse for a few moments Patients with hemorrhoids usually do not have a change in bowel habits as does the patient with carcinoma and in carcinoma there is more apt to be a feeling of incomplete bowel movement than there is with the hemorrhoids

Rectal *polyps* are commonly confused with carcinoma Their most common symptom is the passage of blood If they are low in the bowel the patient may awaken at night with a feeling of great urgency to go to stool They do not tend to change the bowel habits greatly and they usually do not bleed with every visit to stool

Diverticula are found in about 40 per cent of patients who reach forty five years of age They commonly cause a cramp like aching pain in the region of the sigmoid and only rarely do they bleed

DIAGNOSTIC PROCEDURES

In my opinion the most important single factor in making the diagnosis of carcinoma of the rectum in the presence of a rectal complaint is to keep it constantly in mind as a possibility A *rectal examination* should be done using the right index finger With a little effort it is possible to feel almost to

the promontory of the sacrum in a lean individual. Carcinomas or polyps can be palpated easily if there is no stool in the bowel. Hemorrhoids, unless thrombosed, are felt with great difficulty. If in doubt, in the female it is wise to do a *recto vaginal examination* with the patient on her back, the middle finger in the rectum and the index finger in the vagina.

An *inspection* is made of the lower rectum using a rectal speculum. Small hemorrhoids or fissures can be easily identified. If a fissure is seen it should be treated by excision or with dilute silver nitrate. If blood and symptoms persist after this treatment, some arrangement must be made to examine the lower bowel with the proctoscope.

X ray examination will not make the diagnosis in many early cases. We must not expect the roentgenologist to demonstrate carcinomas in the part of the colon which cannot be moved by his hand palpating through the abdomen, in other words we must assume that he will miss most of the early lesions of the rectum and lower sigmoid which comprise about half of all cases.

Proctoscopic examination is valuable in the detection of lesions in the lower 16 cm. of the rectum but it is a common experience to see patients with carcinomas that have been missed when they were subjected to proctoscopy. This is usually due to the fact that the patient was improperly prepared. If the instrument because of the presence of mucus, blood or stool cannot be passed at least 16 or 18 cm. into the rectum the patient should have another enema and the examination repeated.

Negative findings by x ray, digital and proctoscopic examinations do not necessarily mean that the patient does not have carcinoma. If there is a suspicion of a neoplasm I have my patients return in a month or less for a repetition of all tests. I know of one instance in which a patient was given x ray and proctoscopic examination by competent men eight times in five weeks before the lesion was finally found. If the patient continues to pass blood he must be repeatedly re-examined until there can be no question of a lesion being missed.

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an area where the peritoneum and some of the underlying muscles can be resected

The preoperative impression of fixation is often not borne out when the abdomen is opened. In general we consider that every patient is entitled to a radical resection if there are no metastases to the liver if there are no obviously involved lymph nodes beyond the field removable by surgery and if structures to which the tumor is adherent can be removed without killing the patient.

Age is no contraindication to resection. Patients of seventy, seventy-five and sometimes eighty tolerate this operation fairly well.

Unfavorable prognostic signs are fixation, marked loss of weight, persistent fever and complete obstruction.

PREOPERATIVE PREPARATION

Patients having no signs of obstruction, no distention and little cramping, nausea or vomiting are put on a low residue diet containing little or no roughage. They are given $\frac{1}{2}$ to 1 ounce of mineral oil each night unless they develop a diarrhea. Each morning and evening they are given $1\frac{1}{2}$ pints of a warm salt solution by enema. This preparation is carried out until it is felt that the bowel is thoroughly decompressed and clean, which usually takes three to seven days. The patient should be up and around during this time. Hemoglobin estimations and blood counts should be made and if the hemoglobin is below 70 per cent it is wise to give one or two blood transfusions a day or two before the operation. It is routine practice to have a compatible donor present the morning of the operation. If the patient is arteriosclerotic a determination of the total nonprotein nitrogen in the blood is usually made. The result will provide a basis for an estimate of the patient's ability to withstand a long illness. In the male it is well to know of the presence of an enlarged prostate but no treatment for it is given preoperatively unless there is marked urinary retention. We routinely give patients 50 mg. of vitamin C and 10 mg. of thiamine hydrochloride daily during the period of

preoperative preparation. A stool culture for amebas should be made and if they are found a short course of treatment with emetine and carbarsone should be given before operation.

COMPLETE OR ALMOST COMPLETE OBSTRUCTION

If complete or almost complete obstruction of the colon by the tumor is present the first consideration is the relief of the obstruction. The problem in obstruction of the large bowel is different from that in obstruction of the small bowel. The ileocecal valve is competent in many cases and will not allow material to flow from the large bowel back to the ileum. In these instances the use of the Miller Abbott tube with continuous suction will not of course decompress the colon. It will decompress the dilated stomach and a paralytic ileus if that is present. If the obstruction is complete and no gas or stool has been passed for a day or more surgery must not be delayed. Sometimes relief is obtained by small warm enemas given without pressure and by large moist abdominal packs. These patients should be given salt solution with glucose intravenously because most of them are in negative chloride and fluid balance. If they appear very sick a blood transfusion is likely to prove beneficial.

Barium fluoroscopic studies of the colon probably should not be made in these cases if they are great care must be taken to see that barium does not pass beyond the tumor for it is almost impossible to remove it afterwards. To locate the site of the obstruction a rectal examination augmented by inspection, palpation, percussion and auscultation should be made. A flat x ray film of the abdomen will usually show the distended colon filled with gas up to the point of obstruction.

If the obstruction is not relieved shortly preparation must be made for decompressing the distended colon by surgery. The type of operation will depend on the location of the obstruction. *A resection of the colon must never be done in the face of any obstruction.* General anesthesia in a markedly dilated patient carries an added risk of pulmonary complications even though a Levine tube with suction has been placed in the stomach. These patients tolerate local anesthesia very

well and most large bowel obstructions can be relieved under it

Cecostomy

Probably the safest of all decompressing procedures is the cecostomy (Fig 62) The cecum is usually movable and can be reached through a McBurney incision The cecum can be found fairly easily by running the finger along the right parietal peritoneum The reflection of the parietal peritoneum over the cecum can be easily palpated and this loop of bowel brought up Only a small part of the cecum is delivered outside the abdomen The peritoneum is closed moderately tightly around it The fascia is brought up snugly If there is fear of retraction it is well to anchor the cecum to the skin with a few catgut sutures A purse string suture is then placed in a prominent part of the bowel wall using linen, first having protected the wound from contamination by placing wide iodoform strips about it and slightly pinning them between the junction of the skin and bowel and over this placing dressings which have been heavily impregnated on the under side with zinc oxide ointment These dressings are placed flat on the abdomen with one edge tight against the bowel

The cecum is now grasped on each side of the purse string suture with Allis forceps and the bowel may be opened in one of several ways A small trocar such as is used for paracentesis may be inserted through the center of the purse string suture the arm of the trocar having previously been attached to a suction tube When the plunger is pulled out gas and liquid stool may be removed without contamination When the bowel is decompressed a Pezzar catheter with the rubber cut off may be inserted through the opening in the bowel, after which the purse string suture is tied This will allow drainage for some time without soiling Another method of opening the cecum is to plunge a knife through the center of the portion enclosed in the purse string suture and insert a rubber or glass tube into the bowel to allow drainage Almost all tubes tend to become obstructed at times and the surgeon is apt to have a false sense of security because the tube is in place One must make certain that the end of the drainage

incision the omentum being dissected away from the lower margin of the bowel. A few bleeding vessels may need to be tied in this dissection. The transverse colon is delivered outside the wound. A small hole is made through the transverse mesocolon near the bowel through which a glass or rubber tube is passed. The peritoneum is lightly closed around the bowel after packing the omentum around it to act as a seal. The fascia is closed with catgut, the skin with silk, and the abdomen is protected with iodoform and zinc oxide picks as in cecostomy.

If the distention is not great the bowel need not be opened until the next day. If however there is marked obstruction a silk purse string suture is placed in the bowel as was described for cecostomy and the bowel is decompressed immediately. After one day the tube is removed and the anti-mesenteric half of the bowel is cut transversely with a cautery. This allows the two loops to fall apart but the bowel is held up by the tube which passes through the mesentery. Irrigation of both proximal and distal loops of bowel should now be carried on until the bowel is completely clean.

The *advantages* of this procedure are (1) it allows complete diversion of the fecal stream so that the distal loop can be completely cleaned out. (2) the irrigation and removal of impacted material between the tumor and the colostomy is much more satisfactory than with cecostomy. (3) the normal content of the transverse colon is semisolid and the patient is not constantly bathed with liquid stool as he is with cecostomy.

Most of the transverse colon colostomies can be done without infection of the wound. The iodoform and zinc oxide dressings are left in place for seven days only the superficial dressings placed on top of these being changed. At the end of that time all dressings are removed and the skin is generally found to be firmly adherent to the bowel. Stitches are removed and the wound is cared for by cleansing the skin each day with water or oil and placing more zinc oxide dressings over the wound until healing is complete. The tube under the bowel is left in place for ten to twenty days depending on the amount of tension on the bowel.

Infection about either the cecostomy or transverse colon colostomy opening will make itself evident by a steady, throbbing pain which is present whether the patient moves or not. Usually there is a little fever. Oftentimes nothing can be seen grossly, since most infections that do develop around the lesions are fairly deep. They can be drained by removing a suture and inserting a hemostat alongside the bowel. They almost never enter the abdominal cavity and simple drainage is all that is usually needed.

Occasionally the mucosa in colostomies becomes edematous after the bowel is opened. It may swell and look waterlogged. The tube for drainage can be passed as usual and the edema will gradually disappear.

Sigmoid Colostomy

The easiest of all colostomies is the sigmoid colostomy (Fig 62). For inoperable lesions which are in the rectum or lower sigmoid it is the best procedure, but if there is any likelihood that the opportunity for performing a radical resection of the bowel will present itself, the sigmoid colostomy is not indicated.

The sigmoid can be identified by the appendices epiploicae which are attached to it. In acute obstruction due to an obviously inoperable lesion, sigmoid colostomy can be done under novocain anesthesia using a lower left paramedian incision. The bowel is delivered and handled just as in the transverse colon colostomy. The operation may also be carried out through a left McBurney incision.

About 40 per cent of patients who reach forty-five years of age have diverticula of the sigmoid colon. In the face of obstruction these become dilated and very commonly those near the tumor are infected and the surrounding tissue is inflamed. Thus is one of the risks in sigmoid colon surgery. These diverticula not uncommonly give rise to abscesses, sometimes to fistulas, and in the presence of many diverticula in the sigmoid one must be on the alert. If the bowel is opened at the time of operation, pressure on the diverticula is relieved and they are much less apt to perforate.

Deep abscesses about sigmoid colostomy wounds are com-

monly associated with a poorly functioning colostomy. The question constantly arises as to whether there is present a paralytic ileus though patients do pass some gas and stool. Drainage of the abscess generally results in complete relief.

RESECTION OF THE COLON FOR CARCINOMA

After the bowel is completely cleaned out whether by enemas without colostomy or by a preliminary colostomy the patient is ready for surgical removal of the tumor. The *pre operative medication* consists of a quarter of a grain of morphine and $\frac{1}{16}$ grain of atropine. A compatible blood donor is at hand. No enema is given the morning of the operation since there is less apt to be contamination if the bowel contents are dry. A catheter is passed into the bladder and is taped there for the duration of the operation. It should barely enter the bladder so that it is not in the way. The catheter will keep the bladder empty during the surgical procedures. A No. 22 or No. 24 F. catheter is placed in the lower rectum. This allows for decompression of the bowel which may be distended with gas and sometimes makes the difference between an easy and a difficult operation. In the female two vaginal douches are given before the patient is put on the table.

The patient is anesthetized with ethylene and ether as given as needed. The abdominal wall is prepared with three washings of soap and water, bichloride of mercury and alcohol. In the patient who has had a previous colostomy or cecostomy a rubber nipple or a gauze pack is inserted into the colostomy opening and held there by adhesive tape. A towel is then sewed to the skin between the colostomy wound and the new incision and over it a rubber dam is sewed to provide a water proof dressing.

In the anesthetizing room the intercostal nerves on both sides are blocked with a 0.5 per cent solution of novocain to which adrenalin has been added in the proportion of 8 minims of adrenalin to 6 ounces of novocain. Injections are made through multiple puncture wounds at the medial edge of the ribs and are continued down as far as the crest of the ilium. Most of the novocain is injected just as the needle enters the fascia and as it goes through it. If this is practiced on the

cadaver it will be seen that about 100 to 120 cc of novocain will serve to block completely the intercostal nerves on both sides

The patient is now brought into the operating room. A left paramedian incision is made, extending from the symphysis to a point above the navel. Adequate exposure must be had. The abdomen is explored. The liver can be palpated easily. Small metastatic growths can be palpated without difficulty. Occasionally there are small grains of sandlike nodules palpable on the dome of the liver. These may be scars and unless they are more than a millimeter in diameter it can be assumed that they are not metastases. About two thirds of all patients with carcinoma of the rectum and sigmoid have metastases to the lymph nodes. Palpation is a very unreliable guide. Very large nodes may have no metastases and very small ones may contain them. In more advanced tumors the growth may be fixed to the lateral abdominal wall to the bladder to the uterus or to another loop of small intestine. If there is any possibility of making a successful resection of this adherent area, it should be attempted.

Sigmoid Carcinoma

Tumors in the sigmoid which can be lifted out of the abdomen should be removed by an obstruction resection type of operation. If the sigmoid does not come up easily the attachment of the lateral parietal peritoneum can be freed without difficulty (Fig. 63). When the bowel is pulled toward the medial side the junction of the parietal and visceral peritoneum is easily seen and this peritoneum is split with the scissors without bleeding. It may be freed high up into the splenic flexure and down into the pelvis so as to give adequate mobilization. The bowel and tumor are then delivered outside of the abdomen. Care must be taken to preserve an adequate blood supply to the remaining bowel.

As cancer spreads primarily by lymphatics and not along the length of the bowel it is only necessary to resect $1\frac{1}{2}$ or 2 inches of the bowel on each side of the tumor. The important thing is the widest possible resection of the lymph bearing area which follows the blood vessels. The peritoneum may

be split in a V shaped manner down into the root of the mesentery just to the superior hemorrhoidal artery. The fat is retracted, the blood vessels grasped and cut between hemostats, and when the wedge shaped block of mesentery is freed to the bowel, the remaining raw edges of mesentery are lightly approximated with catgut sutures. This prevents herniation through the mesentery.

When there are many large nodes down to the superior hemorrhoidal artery, this artery too may be cut in order to remove the nodes. This carries some risk, as the principal blood supply to the distal loop is destroyed. However, if the mesentery of the distal loop has not been freed too much in delivering the tumor, circulation is adequate, and even if it has been freed widely, the distal loop almost never dies below the peritoneum.

The tumor and its lymphatic bearing mesentery, having been freed, the bowel is delivered out of the abdomen, the peritoneum is closed snugly around it, the fascial closed skin is closed with silk, and two or more button tension sutures are used. The bowel is then crushed between Payr clamps on each side, the usual iodoform and zinc oxide packs are applied under the clamps, tight against the bowel, and the bowel is cut across between clamps with the cautery immediately. This can be done safely when the wound is protected as described, and there is much less chance of implantation when the tumor is removed immediately. The walls of the two loops below or deep to the remaining clamps are brought together with two or three catgut sutures, and the clamps are tied together with silk or catgut. The next day the clamps are removed, the bowel is opened, and one prong of a hemostat or spur crusher is then passed down each loop of bowel for 1 to 2 inches. This is clamped tightly together and will be allowed to remain until pressure causes necrosis and it becomes free of itself after four to seven days (Fig. 63). A catheter is placed in the proximal loop as soon as the bowel is opened, and it is irrigated with 4 to 6 ounces of water in an effort to get gas to pass. The proximal loop is irrigated once or twice daily until gas or stool passes. Occasionally the distal loop will retract $\frac{1}{2}$ to 1 inch below the skin edge. If

the mesentery and the bowel have been joined as described it will not settle below the peritoneum and if a small piece is placed alongside of it, peritonitis will not develop.

With this type of operation the patient must return in about three months for closure of the colostomy wound. This is done under novocain anesthesia incision being made through the skin just wide to the mucocutaneous line. It is carried down to the peritoneum, the peritoneum should not be opened but should be pushed back so that the entire bowel can be dropped below the fascia. After the bowel is thoroughly freed the skin is dissected off of the opening of the colostomy and the rolled out edge of the mucosa is cut and freed so that on all sides the mucosa is flexible and not adherent to adjacent scar tissue. The edges of the mucosa are then brought together with catgut sutures so as not to embarrass the diameter of the bowel. The effect of the spur crusher has made this larger than normal so there is little likelihood of stricture. The muscle and fascia of the bowel should then be closed with linen or silk sutures the whole thing dropped beneath the fascia which is closed with catgut. One small wick for drainage should be left through the fascia down to the bowel. The skin is closed loosely with interrupted silk sutures. The trick in closing colostomies is to free them so they drop back below the fascia without any tension. Occasionally these heal but if the bowel has been freed before it was dropped below the fascia they close spontaneously after a few days or weeks.

ABDOMINOPERINEAL RESECTION FOR CARCINOMA OF THE RECTUM

In lesions of the lower sigmoid or rectum and particularly those at or partially below the peritoneal reflection the entire rectum must be sacrificed if a radical operation is to be done because in this location the lymph drainage is not only upward but is also laterally along the middle hemorrhoidal arteries on the superior surface of the levator ani muscle.

I have found the most satisfactory operation to be that of Miles. The patient is prepared in the previously described manner. The incision is the same. After exploration the high

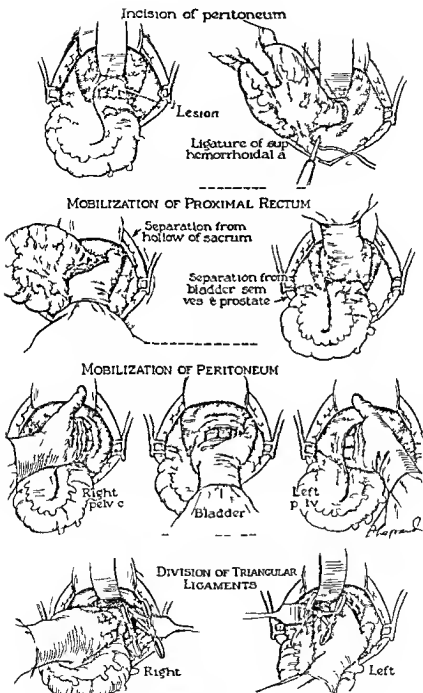
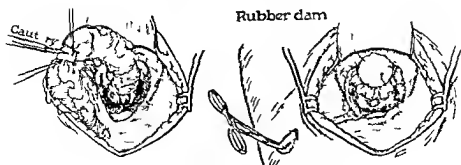
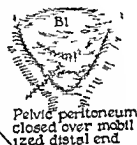


Fig 63—Abdominoperineal resection of the rectum

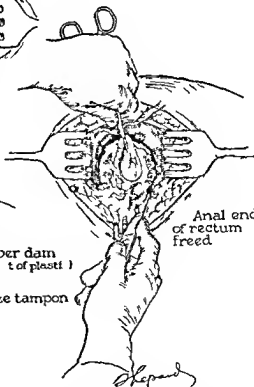
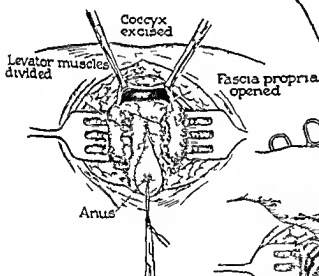


Bowel divided between ligatures and ends capped with rubber dam. Proximal end brought out thru abdom. stab wound.



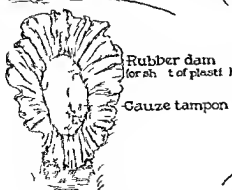
Pelvic peritoneum closed over mobilized distal end.

PERINEAL PART OF OPERATION



Anal end of rectum freed.

DRESSING



Rubber dam (or sheet of plastic)
Gauze tampon

Fig 64—Abdominoperineal resection of the rectum (continued)

est point along the superior hemorrhoidal artery that can be removed and still leave an adequate blood supply to part of the sigmoid is chosen for the point of resection. This is usually 1 or $1\frac{1}{2}$ inches above the promontory of the sacrum. The peritoneum of the mesentery of the sigmoid is split on both sides from the bowel down to the point of ligation of the artery. A blunt scissor is then used to free the peritoneum laterally to the brim of the pelvis an assistant grasping the peritoneum as it is cut in a U shaped manner as shown in Figure 63. These flaps of peritoneum on each side are freed for 2 or 3 inches on each side. On the right side the ureter is often lifted up with the flap. On each side the ureter where it passes over the iliac artery is about $1\frac{1}{2}$ inches lateral to the midline. If fear is felt it can be identified easily and avoided.

The next step is to free the superior hemorrhoidal artery and the mesentery. This is done by passing a finger through the soft parts at the promontory of the sacrum. The finger can be brought up on the other side deep to the artery and as the soft parts are separated the hand can gradually be pushed down along the hollow of the sacrum so that the entire bowel and its mesentery will be lifted free almost to the sacrococcygeal joint in back. This dissection is carried out as far as possible around the front of the bowel between the rectum and bladder or rectum and uterus. The fascial plane here is very easily identified and there should be very little hemorrhage.

The point for resection of the superior hemorrhoidal artery having been chosen the artery is grasped between heavy hemostats and cut and tied with a silk suture. The smaller vessels leading up to the bowel are also crushed between hemostats and tied and the bowel having been well freed is now tied with two heavy silk sutures about an inch apart. The wound is now well surrounded with lap pads a lap pad is placed under the bowel between the two ties and the bowel is severed with a cautery between the ligatures. A piece of rubber dam about 4 inches square is used to cover the ends of the colon. Another silk suture is used to tie this tightly over the end of the bowel. This gives an impervious dressing. There is no contamination. This is done on both loops. All of

the lip pads are discarded. The distal loop of bowel is now pushed down into the pelvis and the loose peritoneal flaps which were previously fashioned are now grasped and their edges are approximated with catgut sutures to make a new pelvic floor.

Sometimes with large tumors this pelvic floor is pushed upward almost to the anterior abdominal wall. As soon as the tumor is removed however it will fall back against the hollow of the sacrum. If flaps of peritoneum cannot be obtained easily it is possible to use the uterus or the tubes to help fashion this pelvic floor. The peritoneum can be moved long distances so if there is an inadequate amount of peritoneum remaining on one side a peritoneal flap can be freed and swung across to the other side to close the defect.

If the colostomy is made through a midline wound there is more apt to be a hernia and there is greater likelihood of wound infection than if it is brought out through a separate incision. We usually like a McBurney incision on whichever side the bowel falls easily. The peritoneum and fascia on the side on which this incision is to be made are grasped and held with the skin so that the incision through the skin and fascia muscle and peritoneum will lie in line. The McBurney incision is about 2 inches in length. The fascia is split, the muscles retracted, the peritoneum opened and a rubber covered clamp is passed through the McBurney incision into the abdomen to grasp the rubber covered end of the bowel which is gradually brought out through this opening. It should fit rather snugly. The bowel need not be sutured to the peritoneum, fascia and skin. It may be necessary to reapproximate the fascia with one or two catgut sutures, the skin is closed with silk. The omentum is now brought down as a sheet between the bowel and the laparotomy wound and the original incision is closed with catgut button tension sutures and the skin with silk. The two wounds are now separated by placing a light dressing over the laparotomy wound and over this a wide crinoline lined adhesive flap is anchored between the colostomy and the line of incision. This is impervious to water and prevents the line of incision from becoming contaminated. The dressing around the col

ostomy wound is made of the usual iodoform and zinc oxide packs and before the patient leaves the operating room this colostomy is opened

The patient is now turned on his face the table flexed. The body is held off the table by padded sandbags so that weight is borne on the iliac crests and on the shoulders. The perineum is washed with soap and water and the rectal catheter is removed. A silk purse string suture is sewed around the anus tightly tied and a raquet incision starting about an inch above the sacrococcygeal joint in the midline is carried laterally to enclose the anus. The incision is made to the bone. The sacrococcygeal joint can usually be found. It is incised the coccyx grasped with a heavy instrument and excised (Fig. 64). The incision is then carried through the perirectal fat on each side. The fascia propria is now grasped beneath the removed coccyx it is incised transversely exposing the bowel which can be easily identified. The fascia propria is opened widely the finger is passed along the bowel laterally and between clamps the levator ani muscle on each side is cut as far laterally as possible. The stump of the bowel is now pulled down through the opening and the bowel is freed from the bed of the prostate or vagina. With care and a dry field the bowel can be freed from the prostate or vagina without perforating either one. In the male a catheter may be left in the urethra to help identify it if the growth is on the anterior wall of the bowel low down. The urethra should not be injured in the uncomplicated case.

After the rectum is removed and bleeding controlled a large sheet of thin rubber dam is placed in the posterior wound in the hollow of the sacrum. This is packed with gauze dressings to support the pelvic floor and to act as a hemostatic agent. It can be removed painlessly at the end of forty eight hours by simply removing the gauze picks piece by piece. This posterior wound is now irrigated two to four times a day with boric solution.

Postoperative Care

Each patient is given a transfusion of 500 cc. of blood at the end of the operation. Fluid balance is maintained by intra

venous fluids until the patient can take fluids by mouth. The ligatures and rubber dressing over the end of the terminal colostomy are removed before the patient leaves the operating room.

The next morning a 22 F catheter is inserted into the colostomy opening until it turns the first corner and 4 to 8 ounces of warm water are injected in an effort to obtain gas. This is repeated in the evening. On the second postoperative morning and every morning thereafter the patient is given an enema of a pint of warm water through the colostomy. This is continued throughout his hospital stay.

The midline abdominal wound dressings beneath the adhesive apron are changed as needed. The zinc oxide and iodoform gauze dressings about the colostomy are not changed for seven days unless there is strong suspicion of infection. The superficial dressings placed on top of the zinc oxide dressings are changed as needed. The waterproof zinc oxide dressings will be much soiled at the end of the week but the wound will be found to be clean if the dressings were properly applied. Skin stitches are removed at the end of a week.

The posterior wound is kept clean by irrigations of warm boric acid solutions. The edges of this wound are kept apart by adhesive strips applied near the edge of the wound and tied together in the front of the body, enough pull being exerted to allow free drainage.

Vitamins B₁ and C are given daily. The blood is kept at a normal level by transfusions if needed.

Catheterization every eight hours is continued as long as need be. About one third of all patients having the abdominoperineal resection are catheterized only once or not at all.

If there has been fear of contamination 1 to 4 gm of sulfanilamide powder is placed in the posterior wound daily. If a dirty gray membrane forms a small pack soaked in Dakin's solution is placed on the floor of the wound well away from the peritoneum and left there for a while. This will tend to remove this necrotic material in a day or two. Excess granulation tissue is removed by a scissors or by silver nitrate. These posterior wounds heal in three or four months.

Most patients are able to be out of bed in fourteen to seven

teen days. The average patient can leave the hospital about twenty five to twenty eight days after operation.

The patient is taught to give himself a 1 pint water enema each morning. If difficulty is experienced in injecting the water, the catheter can be passed through a rubber nipple and this is then used as a washer to prevent leakage.

The diet must be regulated so that the stools are firm and somewhat constipated. If the stools are loose, less fruit and vegetables are eaten; if too solid, more fruit and vegetables are eaten. Almost any intelligent patient can be taught to take care of himself without the use of a colostomy bag. A doughnut dressing of gauze is placed around the colostomy opening and a piece of oil sill rubber or a simple waterproof ice box jar cover purchased in a ten cent store is placed over the gauze as a waterproof dressing. This dressing is held in place by a two way stretch elastic undergarment purchased in any general store. The single enema in the morning takes care of the movement for the day as soon as a habit is established. If there is movement during the day, if the stools are kept hard and constipated, the stool can easily be discarded with a small piece of gauze. Any cooperative patient can get along with this scheme without trouble unless he is subject to attacks of diarrhea. At such times he may need the help of a colostomy bag.

Postoperative Complications

Fever—In uncomplicated cases patients often never have a temperature above 100° F. and are fever free after four to six days. A temperature of 101° or possibly 102° F. on the day after operation is not rare but more than this calls for investigation especially if the temperature remains elevated.

The commonest cause of an early postoperative rise in temperature is a pneumonia or postoperative collapse of the lung. Both of these can be diagnosed by physical findings or x ray. We insist that all of our patients move their legs frequently, that they take six or eight deep breaths several times a day and the nurse must see that they are rolled frequently. Patients with pulmonary collapse are given steam inhalations, frequent change of position and pounding on the back.

plus one of the sulfonamides. Very rarely a tracheal catheter with suction or a bronchoscopy may be needed if the lesion was not discovered early.

Cystitis is a common cause of fever. It is a fairly common complication that usually does not make its appearance until five to eight days after surgery. These patients should all have a urine examination at least twice a week postoperatively.

Wound Infections—Wound infections are characterized by steady throbbing pain and a feeling of tenderness to pressure over one part of the wound and not over another part. *Do not probe wounds* until you are certain that there is infection present. If there is wound infection open it widely. Usually the infection involves only the subcutaneous fat and if the wound is opened widely and then packed with iodoform gauze with warm moist dressings no serious damage is done.

Wound Disruption—In cancer patients wound disruption is not as rare as I would like. The commonest symptom is a sudden gush of serosanguinous fluid saturating the dressings. Frequently these patients have been troubled with a chronic cough or a sluggish bowel amounting almost to a paralytic ileus. When the dressing is changed the wound edges may have separated in a small area and red colored serous fluid exudes from this. With a good light the opening is seen to lead into a cavity and if the edges of the wound are separated slightly with sterile instruments a piece of omentum or bowel can be seen free on the abdominal wall.

Disruption usually occurs one or two days after the silk skin sutures are removed. As soon as disruption is discovered the wound with its protruding omentum or bowel is covered with sterile gauze and the abdomen is tightly strapped with adhesive tape over the dressing. The patient is immediately taken to the operating room. *Do not use general anesthesia.* The abdomen and protruding viscus are cleaned with soap and water and then a 0.5 per cent solution of novocain to which adrenalin has been added (8 minims of adrenalin to 6 ounces of novocain) is injected through the open edges of the wound perpendicular to the length of the wound. The protruding viscus is replaced, omentum being placed between it and the

abdominal wall if the omentum is visible. The intra abdominal contents are disturbed as little as possible. Four to 8 gm of sulfanilamide powder is sprinkled into the peritoneal cavity and the wound is closed by through and through button sutures. These enter the sl in about 1 inch lateral to the wound edge, are carried straight through the muscle, fascia and peritoneum and are then brought out in the same manner on the opposite side of the incision. The next button suture is placed beside the first. From five to ten such sutures are placed in this manner. The buttons are not tied until all are in place. It is seldom necessary to place stitches in the fascia. An occasional silk stitch may be placed in the sl in.

Postoperatively frequent warm dressings are applied and sulfanilamide is given in sufficient dosage to maintain therapeutic levels. These patients sometimes develop a paralytic ileus and usually a Levine tube is passed into the stomach and left open for forty eight to seventy two hours or until peristaltic activity is resumed. This simple and old fashioned treatment will suffice for most patients. There is a low mortality if general anesthesia is avoided.

INOPERABLE CARCINOMAS

The patient who has liver metastases and in whom the primary tumor was removed has the easiest death of any in this group since he usually has a gradual wasting away without too much pain. The person with a fixed tumor and metastases to the liver, the tumor being left in place ultimately is the victim of severe pain due to the pressure of the growing tumor. These patients often require large amounts of morphine. Almost all in this group should have a colostomy in order to prevent obstruction. The colostomy will be cared for as previously described.

In general I think a certain philosophy applied to the treatment will help in caring for these patients. The patient should not be told he is going to die of cancer. He should be made to understand that he will have periods of exacerbation and remission. His family should be told what they are to tell the patient and everyone repeats the same story. This may be that he has an ulcer and usually, of course he does have an

ulcer which is malignant. The doctor can sidetrack the issue much easier than the family.

Patients with inoperable cancer should be given adequate amounts of vitamins and if they are passing much blood it is well to give at least 1 mg. of vitamin K daily. If the bleeding is unusually severe the dosage may be increased to 1 mg. every two to four hours until the bleeding stops. These patients all need sedatives. Before the pain becomes severe they should be given a 3 grain capsule containing $\frac{1}{2}$ or 1 grain of codeine with enough lactose to fill the capsule. This sedative should be taken at regular intervals of four to six hours. As the pain becomes more severe the dose can be changed without the patient's knowing it. Morphine in gradually increasing doses can be substituted and very often a dosage of 1 or $1\frac{1}{2}$ grains of morphine can be reached without the patient's realizing there has been any great change in his sedation.

The patient may wonder why he is not gaining weight and getting stronger. He is reminded that a few days ago he felt better and that he is in another period of remission such as was described to him previously. He must have patience. Many of these patients can be carried to the day of their death without their realizing that they have an inoperable growth.

Sometimes a patient realizes that he has an inoperable and ultimately fatal carcinoma. Sometimes he knows too that his family is aware of it. However, if he does not know of the family's knowledge of his true condition and is told that he will feel better in the course of time, he is enabled to put up a false front, thus helping to make life more liveable for all. It is possible for him and the family to play a little game completely disregarding the idea of the ultimate outcome of the disease. These patients can plan vacations and some of them can take them. They can carry on many of their ordinary activities without thought of the impending outcome.

TWO REVEALING CASES OF RECTAL HERNIATION

CHANNING W. BARRETT, M.D.

HERNIATIONS of the rectum are known to the lay and medical world as prolapses. Two cases from my practice point so plainly to their being herniations and illumine so many truths concerning them that they are described here.

CASE I: PLASTIC OPERATION WITH PROMPT AND COMPLETE RECOVERY IN EARLY RECTAL HERNIATION

Mrs. N., aged sixty-two years, was operated upon thirty years ago for laceration of the perineum and hemorrhoids. The operation improved the perineal condition, but the rectal condition grew steadily worse as a mass tended to protrude more and more from the anus. Tissue in and around the rectum became swollen and inflamed with increasing frequency. The patient's distress was intolerable, causing her on occasions to call a physician during the night to administer a hypodermic. The patient was nervous, hysterical, irritable, and unmanageable and suffering from severe proctophobia.

Examination revealed a rather large woman who was plainly in great distress, both physical and mental. A bulging, reddened, inflamed mass with irregular, ragged borders protruded from the anus, surrounded by sphincter and muscle, describing a circle $1\frac{1}{2}$ inches in diameter. Palpation of the mass showed it to be firm and indurated. Rectal examination proved to be painful but revealed a pelvic floor cleft dilated two and one-half to three times its normal size and filled with thickened rectum. The patient was advised to have hot applications, sulfathiazole ointment, and alkaline enemas for a few days preparatory to operation.

The patient entered Wesley Memorial Hospital for an intrasphincteric hernioplastic operation, which was performed as follows:

1. An incision was made at the mucocutaneous junction just inside the dilated sphincter muscle, encircling the mass.

Gynecologist, Wesley Memorial Hospital

The much thickened end of the bowel was picked up and dissected away from the sphincter and dilated ring of the

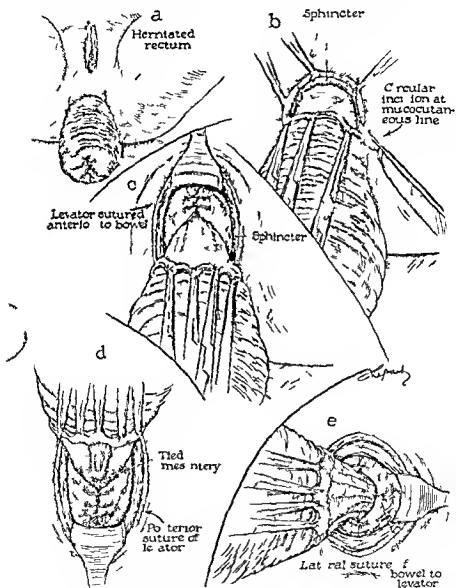


Fig 65—Technic of hernioplastic operation

pelvic floor. Masses of infiltrated connective tissue filled with veins and thrombi had to be dissected from muscles

2 With the rectum held back ward two cutgut sutures brought the levator ani muscles together in front of the rectum. With the rectum now held forward three sutures brought the levatores muscles together back of the rectum. The rectum was attached at the sides to the levatores. This narrowed the pelvic floor opening to proper size.

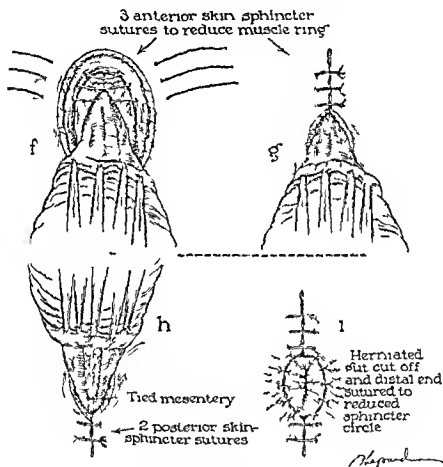


Fig 66—Technic of hernioplastic operation (*continued*)

3 The ring of the external sphincter was decreased in size by three sutures through the skin in front and two behind and the rectum was caught by the suture nearest the gut.

4 The gut was now amputated high enough to take off its thickened end and the cut end was attached to the reduced ring of the external sphincter completing the hernioplastic operation.

The recovery was without incident except for a little swelling of tissue and considerable pain in distress. Subsequent examination showed a perfectly normal appearing sphincter ani rectum and a sufficiently tight levator ani ring.

This case demonstrates the advantages of a hernioplastic operation when performed in cases of rectal herniation before the herniations are large enough to bring about degenerative circulatory changes in the tissues leading to necrosis after operation if not before.

CASE II REPEATED OPERATIONS WITH EVENTUAL NECESSITY FOR CREATION OF AN ARTIFICIAL ANUS IN SELECTED RECTAL HERNIATION

Mrs. W., age sixty six years, suffered severe childbirth injuries in early womanhood. Household duties incident to caring for a large family called for long hours of hard labor, and a large rectocele developed. Nineteen years ago her husband suffered a stroke and in a tremendous effort to carry him to his bed the rectum was herniated the size of an egg. Care of her husband necessitated heavy lifting and the herniated mass became larger. Upon sitting and lying the patient noted that it would disappear but upon working and lifting it would come out.

Five years ago Mrs. W.'s husband became lost in a storm. She found him unconscious a distance from the house and carried and dragged him home and up the stairs. From that time on the protruding mass was $2\frac{1}{2}$ inches in diameter and growing. She consulted a physician but he delayed active treatment, telling her to return later. She was a hard worker but hesitated to leave the house because this herniating mass impeded walking. While at first it was out only occasionally, later it tended to remain out for progressively longer periods.

I was called to see the patient at the hospital. The mass with the patient at rest was seen to be well back with a diameter of 4 inches. A large rectocele was present. At other times the mass was out in full and at least 6 inches in diameter. It could be pushed back but when this was done a large rectocele $2\frac{1}{4}$ inches in diameter bulged from the vagina. I could introduce my fist (a large one) into the pelvis through the rectum or vagina.

With the large rectocele and rectal herniation the patient had practically no lower wall to the abdomen. The muscles could be felt off to the side but there was extensive diastasis. One who could view this and call it prolapse of the rectum must forget what hernias are in all other regions.

First Operation—I was hopeful of limiting the necessary surgical procedures to one sitting but here was a woman much older than her years feeble with a marked heart lesion but determined to get well.

For a successful operative result it was apparent that the separated levator muscles from coccyx to the pubic bones must be united. This was attempted and required a great deal of work in a feeble woman with poor tissues. An extensive vaginal flap was raised to reach the muscles in the vaginal area and an extensive vegino hernioplastic operation was performed in the shortest possible time.

Then the operation upon the rectal region was performed just as described in Case I except that each step was carried out more extensively. There was no muscle to gather from the coccyx to the point where they had been brought together vaginally. More bowel was amputated but it was evident that if we amputated too much bowel and left the muscles widely separated much more of the abdominal contents might herniate.

The hernioplastic operation was completed with results that presented a highly satisfactory appearance. The patient was in good condition but there was some question whether she would react well and whether the tissues would heal. If they healed she was cured; if they necrosed a second repair might have to be done. Sloughing due to ischemia of the tissues was rather extensive but the patient made a good general recovery. There were no abdominal symptoms. It seemed to make little difference how long the bowels lay dormant. As the sloughing took place the tissues drew together, but they were slow to heal sufficiently to permit additional surgical procedures. As the patient was developing severe nostalgia and was finding it possible to control the bowels she was allowed to go home.

Second Operation—Several weeks later a physician was

called and found present a large hard fecal mass. About one week later I was summoned and found an extruded mass of bowel as large as the first. The patient was again sent to the hospital the herniation was reduced and by position and packing it was not difficult to keep it inside but there seemed no approach to readiness for another operation from below. We knew now that there was present a large mass of loose bowel with lengthened mesentery which would protrude whenever the opportunity offered itself. As the patient was growing stronger and appeared able to withstand the procedure a laparotomy was decided upon after consultation. Only by exposing the abdomen could a decision be made between a temporary colostomy to divert the fecal stream, a permanent colostomy with resection of the lower end of the bowel and an operation consisting of pulling up the bowel and attaching it to the fixed abdominal structures.

The abdomen had been felt and there had been no abdominal symptoms but I was not prepared for the appearance of normalcy that presented upon opening the abdomen. No pathologic changes in the lower bowel could be detected except that the mesentery the whole distance of a long sigmoid was long expansive and had a traumatized chewed appearance with many old white scars but nothing evidencing new trauma. This wide expansive mesentery was pleated in many places taking up much slack.

The sigmoid was drawn up and the lowest possible portion was attached to the right broad ligament close to the pelvis. It was then attached at intervals across the abdomen to the left side and to the psoas muscle and to the left abdominal wall.

The patient's recovery was without incident except that for one day there was a slight bowel distention. Again it seemed to make little difference how long the bowels lay dormant they responded readily when oil was given. Improvement of the hernial wound was more rapid than after the first operation the patient's general condition improved and the open rectal end was drawn nearer the skin than before. We wanted a much better condition of the wound however before undertaking another hernioplastic opera-

tion Nevertheless because the patient urged the need of stopping expense and the homesickness was returning, we promised to operate in another week

Third Operation—We had no trouble in exposing the muscles and making a hernioplastic repair that seemed as satisfactory as the one made at the first operation The tissues were more freely supplied with blood but some granulations were still fresh The sloughing was not so extensive but suppuration occurred enough to spoil our line of suturing As healing took place the bowels were well controlled and no protrusions took place The patient went home happy and quite content

During the next six months the patient improved physically and mentally, and grew to look years younger Her greater activity however caused the tissues to overcome the attachments that had been made and a protrusion $1\frac{1}{2}$ inches in diameter occurred The tissues presented a very good appearance for operation During the next ten days the protrusion grew to a diameter of $2\frac{1}{4}$ inches and the patient became very apprehensive We wished to take advantage of the improved condition of the tissues before a mass should descend to disturb the circulation

Fourth Operation—Upon straining by the patient the extruded mass reached a diameter of about 3 inches In the center was the bowel anteriorly a bulging tissue which appeared to be a hollow sac and was thought to be the peritoneal sac and posteriorly a bulging doughy mass interpreted to be a portion of the mesentery The bowel was again freed from its skin and scar attachments when a mass at least 5 inches in diameter bulged through the large perineal opening The bowel was freed and brought down until a normal sized healthy looking section of the sigmoid was reached where amputation was done A large mass of the chewed up mesentery was tied off and the bulging peritoneum of the posterior cul de sac which was much thickened was tied off and closed with sutures The tied mass of mesentery was pushed back and the pelvic fascia sutured over it

Next beginning at the coccyx a half of the pelvic floor which was in good condition was attached to its fellow of

the opposite side by interrupted catgut sutures bringing the rectum as far forward as possible to prevent any protrusion of the peritoneum of the cul de sac. The bowel was now disposed of by making a very moderate sized puncture wound in the center of the perineum just posterior to the vagina and drawing the end of the bowel through this opening and attaching it to the skin. This we felt might help to avoid two unpleasant possibilities first the coming down of the peritoneum and second the dissolution of the line of sutures if the very extensive wound suppurated.

This operation leaves the rectum with a snug collar and good pelvic floor support which will help to carry the fecal contents. Its present position is far superior to attachment to the original sphincter which after repeated operations and suppurative destruction is capable of but little action and offers the likelihood of having a line of sutures give way leaving the bowel unattached.

The patient recovered without untoward symptoms and healing took place by first intention. Bowel control is very satisfactory as she has a voluntary movement in the morning with no further movement unless looseness is present.

This case illustrates the inadvisability of delaying operation in the case of a developing herniation until the tissue becomes so damaged that healing is uncertain or completely out of the question. It also demonstrates that the muscular support necessary for a hernioplastic operation is present but healing of the tissues is required to make the operation a success.

CONCLUSION

These two cases demonstrate that loosenings and protrusions of the bowel through the pelvic floor as described are real herniations and not prolapse of the rectum. The word prolapse causes the essential pathologic factor separation of the pelvic floor to be overlooked.

TREATMENT OF FISSURE HEMORRHOIDS AND FISTULA IN ANO*

G V PONTIUS MD FACS†

FISSURE, hemorrhoids and fistulas constitute the most common anorectal lesions the surgeon is called upon to treat. Before beginning a discussion of the management of these conditions a brief consideration of the patient to be treated will be of value. The late and eminent neuropsychiatrist G W Hall stated that all patients should have a psychiatric study before being subjected to any form of therapy. In no other field is that statement so applicable as in anorectal disease. Every surgeon knows how the patient with a rectal lesion is prone to procrastinate as to his therapy, how the patient with fissure suffers through one attack after another, each episode being more distressing than surgical eradication, how the patient with hemorrhoids permits bleeding to progress until a severe secondary anemia results, and also how the patient with fistula harbors his infection until many abscesses develop and rupture with involvement of one or both ischio-rectal fossae, thus necessitating more extensive surgery for cure.

It seems fair to ask ourselves why this is so. There are several answers. One group of patients do not seek treatment because of ignorance. They are the so called pile sufferers. They know all the proprietary remedies for itching piles, burning piles and bleeding piles. They believe their condition like baldness and graying hair to be a natural process of aging. Paradoxically, there is another group who are too intelligent—they know they have cancer. Because they have observed blood in the stools or because of the chronicity of their symptoms

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they are sure they have a malignant disease. They avoid the surgeon because of a dread of the verdict. There is still another group who avoid treatment because of the fear of the pain associated with surgical treatment and the poor results reported by their friends and acquaintances. They have been told their hemorrhoids recurred or the fistula was not cured or they were left without control of the rectum.

These are a few of the problems that the rectal patient brings with him when he consults the surgeon. Unfortunately he usually does not confess these fears; in fact, he is more likely to minimize his symptoms, thus believing he will avoid surgery. A few well-chosen words to explain his condition to assure him that it can be relieved and without severe discomfort is effort well spent. His fears allayed, the rectal patient becomes encouraged and cooperative. This however places a greater responsibility upon the surgeon. It is now imperative that he keep his word. He must remember that the patient who has experienced considerable pain has a lowered threshold for pain. When it is necessary to excite discomfort during the examination or operation, the patient should be forewarned. Careful, gentle but complete examination increases this patient's confidence. A well-executed preoperative program carried out by skillful hospital personnel brings him to operation confident and cooperative.

ANATOMY

The *rectum* is the terminal portion of the bowel extending from the promontory of the sacrum to the anorectal junction which is located at the upper border of the anal sphincter. This discussion deals with only the lower portion of the rectum and the anal structures. The *anus* is 2.5 to 3 cm. long. Its upper limit is at the point where the levator ani muscle fuses with the body of the sphincter. The lower 1.5 cm. of the anal canal is lined with skin. Where the skin joins the mucosa of the rectum it is thrown into folds known as the *crypts and columns of Morgagni*. The line formed by this junction is known as the *white line pectinate line* or *line of Hilton*. It is the narrowest portion of the anorectal structure and therefore most subject to injury by hard stools or foreign bodies. The

anal canal points slightly anterior from below upwards Its central axis points towards the umbilicus from the external anal orifice At the upper border of the anal sphincter the rectum turns posteriorly to follow the sacrum

MUSCULATURE—The *internal sphincter* is an exaggerated continuation of the circular musculature of the rectum This thickening begins 3 cm above the anal orifice In cases of long irritation and spasm this portion may become hypertrophic and then the distance from the external orifice is considerably lengthened and the body of the sphincter is much thicker than normal The levator ani muscles are attached to the upper border of the sphincter in a palpable ring which completely encircles the lower rectum The *external sphincter* lies subcutaneously overlapping the internal sphincter For the most part its fibers are circular but the externalmost fibers become more longitudinal in character coursing from the rectococcygeal ligament around the anus and continuing on to insert in the transverse perineal body Posterior to the anal canal there are interlacing crural fibers within this longitudinal portion of the external sphincter It is this rectococcygeal body plus the suspensory action of the levator ani muscle which tend to support the anorectal structures

ISCHIORECTAL FOSSAE—The ischiorectal fossae are formed by the levator ani muscles medially and superiorly and the fascia of the ischiae laterally These spaces are composed of fat and through them course the internal pubic nerves and inferior hemorrhoidal vessels

BLOOD SUPPLY—*Arteries*—Blood is supplied to the lower rectum and anal canal by the superior hemorrhoidal artery which is the end branch of the superior mesenteric artery It follows the hollow of the sacrum posteriorly to the rectum giving off numerous branches which course around the rectum and anastomoses with the middle hemorrhoidal arteries from either side The middle hemorrhoidal arteries are branches of the hypogastric They are relatively small They are however the chief supply to the lower ampullae the prostate seminal vesicles and levator ani muscles The inferior hemorrhoidal arteries are branches of the internal pubic They course across the ischiorectal fossae and divide into variable

and numerous branches supplying the anal portion of the rectum and levator ani muscles.

Veins—The veins of the anorectal structures correspond to the arteries just described. They anastomose freely to form two plexuses which communicate with each other. The internal or superior hemorrhoidal plexus is located in the submucosa and is drained by the superior hemorrhoidal vein from the inferior mesenteric vein which empties into the splenic and is a part of the portal circulation and the middle hemorrhoidal vein which drains into the systemic circulation by way of the hypogastric vein and the vena cava. The inferior hemorrhoidal vein arises from the external hemorrhoidal plexus which is a venous network beneath the skin on the outer surface of the external sphincter muscle. It drains into the general circulation through the internal pubic vein. Many branches from the internal hemorrhoidal plexus join the external plexus. These plexuses form the anastomoses between portal and systemic circulation and comprise the mechanism by which malignancy may extend to either portal or systemic circulation.

LYMPHATICS—Lymphatic drainage is divided at the mucocutaneous line for the most part downward in the anal portion drainage is to the ischioanal and inguinal glands. Above the mucocutaneous line the lower rectum drains laterally along the levator muscle and under the rectovesical fascia. Drainage from the upper portion of the rectum is upwards along the superior hemorrhoidal vessels. This represents the major lymphatic flow. There are however intercommunicating channels between these systems and all pathways may be involved.

NERVE SUPPLY—The anorectal structures have both sensory and sympathetic nerve supply. As with the lymphatics the mucocutaneous junction forms the line of division. Below this line the nerve supply is sensory from the third, fourth and fifth sacral segments and through the internal pubic nerve which accompanies the inferior hemorrhoidal vessels across the ischioanal fossa and supplies the external sphincter muscle, the cutaneous lining of the anal canal and the perianal skin. The anal canal is richly supplied with sensory nerve

endings thus it is extremely sensitive Above the mucocutaneous line the mucosa of the rectum is relatively insensitive its supply being sympathetic from the mesenteric plexus by way of the hemorrhoidal plexus The middle hemorrhoidal plexus comes from the pelvic plexus which also contains motor fibers from the second third and fourth sacral segments These fibers convey inhibitory sensation to the rectal musculature While the rectal mucosa is insensitive to trauma it must be remembered it is extremely sensitive to traction and distention

EXAMINATION OF THE PATIENT

Every patient who is to undergo rectal surgery should have a complete physical examination It should not be assumed that because a relatively minor surgical procedure is contemplated a superficial examination will suffice A minor rectal procedure upon a patient with prostatism may be the exciting cause of an acute retention The early tubercle patient may subsequent to operation, accuse the rectal surgeon of destroying his sphincteric function Bleeding from the rectum will probably not be cured by hemorrhoidectomy in the purpuric or cirrhotic patient

A rectosigmoidoscopic examination should be made prior to anal surgery in all patients excepting those whose lesions are too painful to permit such a procedure Extremely acute fissures strangulated and thrombosed hemorrhoids and abscesses are practically the only contraindications It is very tempting to omit such a procedure when the patient presents large ulcerating hemorrhoids with a history of bleeding but it can be extremely embarrassing to have operated upon him for hemorrhoids then have him return still bleeding and find a benign polyp or malignant growth in the rectum or upper sigmoid

A careful examination also enables the surgeon to evaluate the condition present in the light of the procedure to be carried out In patients with fistula the internal opening may on examination be located If it can be the information will be of great help at the time of operation for if one elects to perform fistulectomy at a time of minimal suppuration (which is most desirable) one may find the internal opening has sealed

and it is found with difficulty whereas when it has been located prior to operation much time will be saved

PREOPERATIVE PREPARATION

The patients are requested to eat lightly of bland foods the day before surgery and to report to the hospital before 7 30 P M The perineum is shaved and 3 ounces of warm cotton seed oil is given as a retention enema through a No 16 urinary catheter Sufficient barbiturate is given to insure a restful night On the morning of operation a cleansing enema of warm saline solution is administered This should be given early enough to insure complete expulsion without hurry before the operation Two hours before operation nembutal grains 1½ is given by mouth Extremely nervous patients may be given a second dose of nembutal before operation Morphine is rarely used because of its tendency to produce nausea Water is permitted with the nembutal and patients accustomed to coffee may be permitted one cup

Position of the Patient for Operation

Three positions on the operating table are very satisfactory depending upon the patient type of surgery to be done and the preference and habit of the surgeon The *left lateral* or *Sims position* is satisfactory for small procedures The *prone jack knife position* is the most universally satisfactory position although the *dorsal lithotomy position* is satisfactory and preferred by many This latter position however is more tiresome and patients with arthritic spines frequently complain of subsequent backache if kept in this position for any considerable time Women frequently object to this position

The *comfort* of the patient on the table is seriously considered A pillow between the knees in the Sims position well padded stirrups for the lithotomy position a pillow under the shins for the jack knife position are all little points of consideration *Draping* should be as light as is consistent with an aseptic technic The patient should be kept warm but perspiring should be avoided if possible

Preparation of the Skin

The perineum is cleansed by scrubbing with a bland soap and water, with pledgets of cotton, and then responded with aqueous solution of merthiolate. If one wishes, a tincture may be used but it is somewhat unpleasant to the patient and in our experience not necessary.

Anesthesia

SELECTION OF ANESTHESIA—To do careful and exact rectal surgery good exposure is essential. This will not be possible until good relaxation of the sphincter muscle is procured. This should be accomplished without distortion of the parts. Regional anesthesia accomplishes these requirements. It is next to impossible to relax the sphincter muscle with any form of gas inhalation. With ether the sphincter is not relaxed until the patient is very deeply intoxicated—an unnecessary danger. Unless relaxation is procured by anesthesia forcible evulsion of the sphincter is necessary for exposure. In such a procedure unnecessary trauma to the tissues occurs and infection may be disseminated.

The type of regional anesthesia used depends upon the individual operator and the case under consideration. In general we favor *circular infiltration* for fissures and hemorrhoids. The operator should proceed slowly and be willing to wait until anesthesia is complete before beginning the operation, for if the patient is hurt because of an insufficient degree of anesthesia he will be in constant fear throughout the procedure. The possibility that the infiltration procedure in the presence of suppuration may disseminate infection must always be kept in mind. It should be remembered also that because the length of time necessary for fistula dissection cannot always be determined before operation the anesthetic effects may wear off before operations are completed.

Sacral, caudal or low spinal analgesia is preferred by many surgeons and we favor it in cases of fistula abscess and an extremely spastic hypertrophied sphincter body.

Vocal Anesthesia—It is important to keep the patient informed as to the progress of events and to give assurance that a successful procedure is being accomplished. His attention

may be diverted by a nurse or resident but never should the technic or the extent of his condition be discussed by assistants, surgeon or nurses. A skilful efficient well disciplined operating team radiates confidence to the patient and is a valuable adjunct to successful regional anesthesia.

TECHNIC OF CIRCULAR REGIONAL ANESTHESIA (HACKENBROUCH)—The *instruments* needed are one 10 cc Luer Lok syringe and one set of fine sharp 1 inch needles for intradermal wheals, one of $2\frac{1}{2}$ inch needles for subcutaneous infiltration and one of 4 inch needles for infiltration of the deeper structures.

Solution—A 0.5 per cent solution of novocain in normal saline has been our agent of choice because it is low in toxicity, nonirritating to tissues and compatible with adrenalin. 10 minims of which are added to 700 cc of the novocain solution. Adrenalin has a vasoconstrictor action that produces a relative ischemia of the field which intensifies the anesthetic effect and in addition prolongs it by slowing the rate of absorption of the anesthetic into the circulation. The latter effect probably lessens the toxic effect of the novocain as well. This solution is used in amounts of 170 to 700 cc depending upon the amount of fatty tissue on the patient. Anesthesia will be complete and long enough for the average anorectal procedure.

Technic—With the finest sharp needle an intradermal wheal is raised on either side of the anus about 3 cm from the anal margin. The patient is always warned of the needle's stab. Through these wheals a circular zone is placed subcutaneously using approximately 5 cc to each quadrant through the $2\frac{1}{2}$ inch needle (Fig. 67 a). It is important to infiltrate slowly and to keep a spray of the anesthetic agent constantly flowing ahead of the needle as it is inserted forward. Care should be exercised that the anterior and posterior midline is completely infiltrated. Now with the same length needle a deeper zone is infiltrated, the needle passing through the subcutaneous zone and parallel to the anal canal outside the sphincterian body. About 10 cc is placed in each quadrant in this manner. Five cubic centimeters is also injected just anterior to the coccyx in the posterior midline. The anterior midline is likewise in

filtrated This is more difficult in multiparous women because of the thinness of the rectovaginal septum About ten minutes are required for this phase of the procedure Sufficient anes

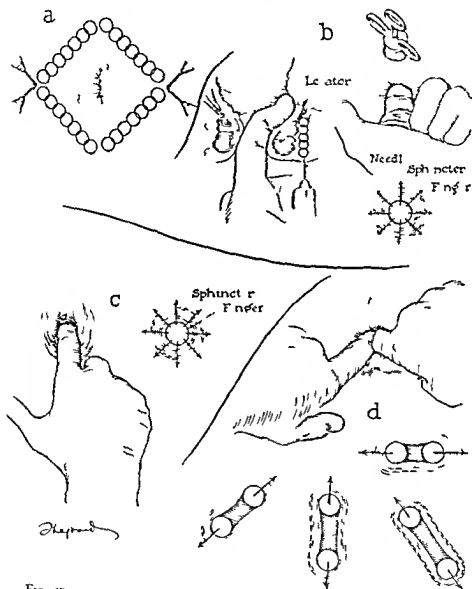


Fig 67.—Anesthesia and division of the sphincter *a* Subcutaneous infiltration *b* Technic of collar infiltration *c* Insertion of finger for beginning division *d* Insertion of second finger for completion of division

esthesia will now be produced to permit the introduction of the left index finger through the anal canal In extremely painful lesions it may be necessary to wait three to five minutes The

patient should be warned that the finger is being inserted and that the operation has not begun. The finger should remain within the anal canal until the anesthesia is completed, the syringe being filled by the assistant. This lessens the chance of contamination.

The long needle is now inserted through the zone already infiltrated and directed toward the tip of the index finger within the rectum which is flexed or hooked over the sphincter muscle. By this maneuver the needle point can be located (Fig 67 b). There will be no danger of puncturing the rectal wall with subsequent contamination and the sphincter can be felt to relax as the anesthetic agent is distributed completely around the lower rectum. Approximately 10 cc is injected into each quadrant. Anesthesia should be complete within five minutes when division may be begun. Division may produce a sense of fullness and desire for evacuation which is due to the sensitivity of the rectum to distention. The patient should be forewarned of this sensation.

Sacrocaudal and spinal analgesia is adequately described elsewhere and will not be repeated here.

Division of the Sphincter Muscles

After anesthesia is procured division of the sphincter body is the next step in all anorectal operating. This may be accomplished by using the index finger or with a suitable bivalve speculum. For the occasional operator the index finger method is probably safer and less damage will be done to the anorectal structures. For the surgeon who has disciplined himself to slowness and patience the instrumental technique is satisfactory. O'Brien and Hartman have shown that if division is properly carried out there is no extravasation of blood in the muscle or rupture of its fibers. This is especially true under regional anesthesia.

Finger Technique—The well lubricated index finger of one hand is inserted just through the sphincter so as to hook the sphincter body. With firm pressure on the anal wall with the palmar surface a rotary motion is carried out (Fig 67 c). If anesthesia is complete the muscle can be felt to fade away or relax. The index finger of the opposite hand is next intro-

duced dorsum to dorsum pressure being made slowly in opposite directions completely around the anus (see Fig 67 d) This procedure should be gently and slowly carried out for several minutes until the muscle no longer tends to contract when pressure is released The amount of time necessary for this will vary with the degree of hypertrophy and spasticity of the muscle In case of severe fibrosis of the external sphincter gentle divulsion may not procure wide dilatation in which instance it is better to do a partial sphincterotomy in conjunction with whatever operative procedure is to be carried out rather than risk tearing of the muscle by forcible divulsion

Exposure of Anorectal Area

Complete exposure of the anorectal area is imperative in good rectal surgery for two reasons (1) the diagnosis should be checked and associated pathologic processes searched for (2) decision can be made as to the type of operation to be performed and the amount of tissue removed The complete operation should be visualized before operation is begun thus cannot be done without good and complete exposure

Technic—When the anesthesia is complete and the sphincter muscles have been divulsed, the anorectal area is exposed by placing a Pennington clamp at the external anal margin in each of the four quadrants Traction is made equally on these first in the direction of the anal axis and then outward as the spokes of a wheel The gloved finger covered with dry gauze inserted into the rectum and withdrawn making pressure on the walls will assist in prolapsing internal hemorrhoids Failure to effect good exposure by this method will be due to poor anesthesia incomplete divulsion or fibrosis of the sphincter muscle

FISSURE IN ANO (PAINFUL ULCER)

Fissure in ano is a longitudinal rent of the lining of the anal canal Ninety per cent of all fissures occur in the posterior midline 5 per cent in the anterior midline and 5 per cent on the lateral wall Practically all those on the lateral wall are due to the passage of foreign bodies which cut the lining, or

to the ulceration of a thrombosed external hemorrhoid. They usually heal and thus seldom require surgical treatment.

ETIOLOGY—The anatomy of the anal canal predisposes to fissure in the posterior midline. The externalmost fibers of the external sphincter run parallel from the coccyx anteriorly separate at the posterior margin of the anus and embrace the anal canal on either side and then fuse at the anterior anal margin. There are interlacing crural fibers at the posterior anal margin which if broken by the passage of an extremely large stool permits splitting of the parallel fibers. If this is extensive enough to overstretch the anal canal the lining will tear at the part which is now lacking muscular support. Tearing of a crypt of Morgagni involving the mucocutaneous junction may occur as the result of an undermining due to infection.

TREATMENT

The treatment of fistula in ano depends on the extent of the pathologic involvement which in turn will depend largely on the duration of the lesion. Very early and superficial fissures may respond to palliative management such as anesthetic ointments, lubrication of the bowel, hot sitz baths and low residue diet. Healing may be complete within a fortnight. Unsatisfactory healing will usually be due to subcutaneous infection with undermining in a deep tear. The skin edges will be rolled in appearance. At the external anal margin the skin is heaped up and becomes edematous, thickened, presenting a pouting mass, the so called sentinel pile. As one separates the buttocks and makes lateral skin traction the rent above the sentinel pile may be brought into view. What appears as a narrow slit upon such exposure with the anus relaxed will be a relatively large ragged ulcer when the anal ulcer is dilated to its normal capacity. The sentinel pile will be sensitive to pressure.

If allowed to go untreated the ulcer may partially heal at least sufficiently so that the bleeding and the extreme burning pain before and after defecation are relieved to an extent that causes the patient to believe he is recovered only to have the symptoms recur upon future trauma. If this process continues over a period of years one of three things will usually happen (1) The rent will extend so far outward that adequate drain

age will permit of granulation and healing (2) A more common result is fibrosis of the pecten or fascia like structure which lies over the sphincter muscle and fibrosis and traction of the external portion of the sphincter with subsequent loss of its elasticity and contracture of the anal canal (3) Anal sinus abscess and fistula develop in the order named They will be considered later

Preoperative Management

In only one respect will routine preoperative preparation be difficult If the lesion is extremely painful and there is much associated spasm proper cleansing of the rectum may offer a problem If so it will be well to have facilities for irrigation available at the operating table so that the ampulla may be emptied after anesthesia is administered

Anesthesia—Circular infiltration

Divulsion—Divulsion should be complete except in those cases with extreme fibrosis of the pecten and external sphincter fibers Here a partial sphincterotomy and pectinotomy are preferable to forcible divulsion

In selecting a surgical procedure for the treatment of fissure in ano three requirements should be kept in mind (1) resection of the fissure margin and bed (2) provision for adequate external drainage of the surgical wound (3) removal of associated lesions that will interfere with the healing of the surgical wound as for example hypertrophied prolapsing papillae and internal prolapsing hemorrhoids One of three methods will meet these requirements depending on the type and extent of the lesion (1) simple incision (2) wedge excision with or without sphincterotomy and (3) quadrant resection

Incision

Simple incision is satisfactory in early cases without sentinel piles or pathologic disturbance above the fissure bed and with little undermining

Technic—(1) Anesthesia circular (2) divulsion (3) exposure A Sims speculum is inserted to protect the opposite wall and traction is made away from the fissure bed

An incision is made from the upper angle of the fissure outward to well beyond the external anal margin (Fig 68 a 1)

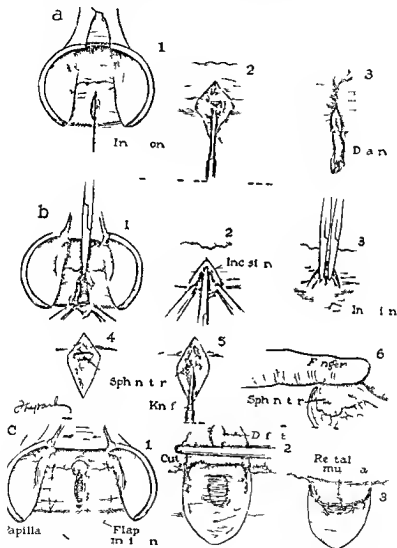


Fig 68—*a* Incision technique *b* Wedge resection *c* Sphincterotomy
 6 method of testing depth of sphincter in section *c* Biles method

Roughly the distance from the external anal margin to the incision's outer end should be twice that from the external anal margin to the inner limit of the incision. This incision

should be deepened to include the subcutaneous fascia and enough of the sphincter muscle to leave the bottom of the incision smooth and free from cross muscular fibers that will act as an obstruction to the passage of stool as determined by the index finger (Fig 68 a, 2) Overhanging skin or granulation tissue is trimmed away from this incision with scissors Bleeding points if any are ligated with fine catgut, a small gutta serena drain is placed in the incision and moist wet packs are applied (Fig 68 a, 3)

Wedge Excision with Sphincterotomy

In the older cases in which there are present more fibrosis undermining of the skin with rolled edges and usually a sentinel pile or benign sinus formation but a normal pectinate line the wedge excision with sphincterotomy is the simplest and most satisfactory procedure

Technic—A suitable self locking bivalve speculum is placed so that complete exposure of the anal canal is procured A careful inspection is made for infected crypts and sinuses The speculum is then set so that moderate tension is made on the sphincter muscle, this helps to identify it The lower borders of the fissure are then grasped with small hemostats and retracted laterally (Fig 68 b, 1) Another hemostat is placed at the upper border of the fissure and pulled downward With the scalpel a V incision is then made on either side of the fissure from the apex to a point opposite the hemostat placed at the lower border (Fig 68 b, 2) This incision extends only through the skin and fissure but does not involve the muscle The incision should be placed far enough away from the fissure margin to remove all overhanging and infected skin The hemostat on the upper border of the fissure is then released and the first two are lifted upward The external V is completed as shown in Figure 68 b, 3, and the ulcer completely excised This gives an excellent view of the external sphincter fibers which are usually fibrosed and hard Partial sphincterotomy is then performed if necessary Hemostasis is secured a flatulence catheter is inserted and a splint dressing applied

Technic of Partial Sphincterotomy—The bivalve speculum

is opened sufficiently to maintain tension on the external sphincter structures as shown in Figure 68 *b*, 4. With a scalpel the fascia like pecten and sphincter fibers are incised from the upper angle of the fissure bed outward in the exact anterior or posterior midline depending upon the location of the fissure. If slight tension is maintained by a bivalve speculum the pecten and sphincter fibers can be seen to retract as they are cut through. A considerable portion of the external sphincter may be encountered and it will be recognized by its circular fibers as it is divided. If the incision is accurately placed in the midline these fibers may be divided as completely as necessary without fear of loss of function provided satisfactory postoperative care is carried out. Healing will occur by fibrosis and the fibers will regain their function.

Technic of Splint Dressing—A No. 16 wing tipped urinary catheter or a Montague flatulence catheter is inserted into the ampulla. The operative area is dusted with sulfathiazole powder then a small piece of vaseline gauze is placed over the anal margin about the tube. Small rolls of sterile gauze are placed on either side of the tube. These are built up as wood is corded until the intergluteal space is filled. These gauze rolls are held in place by strips of adhesive placed transversely across the buttocks in front of and behind the catheter. Sufficient rolls are placed so that when snugly taped there will be moderate pressure exerted upon the anal margin. Such a dressing properly applied supports the anus and prevents subcutaneous oozing and perianal skin edema. The purpose of the flatulence catheter is to permit the passage of gas to warn of internal bleeding and to permit the administration of subsequent enemas without further introduction of a foreign body into the rectum.

POSTOPERATIVE CARE—First Twenty four Hours—The patient is placed in bed with thighs flexed by a pillow under the knees and the head of the bed slightly elevated unless contra indicated by anesthesia. Warm fluids are permitted. Morphine sulfate grain $\frac{1}{8}$ to $\frac{1}{4}$ may be given every four hours if necessary. Usually one or two such doses will be required.

Second Twenty four Hours—The splint dressings are removed leaving the flatulence catheter in place and warm

moist compresses are applied every two hours. The patient is permitted and encouraged to get out of bed at least once during the day. A soft bland diet is ordered and 15 minims of tincture of belladonna is given four times a day.

Third Twenty four Hours — An enema of 4 ounces of plain petrolagar with an equal quantity of warm water is administered through the fistulence catheter with low pressure. The catheter is removed and the patient is permitted to go to stool accompanied by nurse or orderly. A hot sitz bath is given for ten minutes after stool. The warm compresses are continued and a bland general diet is ordered. The patient is allowed to be up and about as he desires. One half ounce of plain petrolagar is given orally morning and evening.

Fourth Day — A hot sitz bath is given morning and evening. The warm compresses are discontinued. Anesthetic ointment is applied externally morning and evening.

Fifth Day — If spontaneous bowel movement has not occurred on the fourth day or by noon of the fifth day, an oil and water enema is repeated before the discharge of the patient in the afternoon. If bowels have moved normally, the patient is discharged in the morning with instructions to return to the office in one week for observation.

SUBSEQUENT CARE — Upon the patient's return to the office the edges of the wound are carefully inspected for pocketing and undermining. If this has taken place it should be immediately corrected. General dilatation is accomplished by carefully inserting the well lubricated finger through the anal canal. This maneuver is repeated weekly until healing is complete.

During the healing process the patient is instructed to exercise extreme cleanliness. He should continue the sitz baths after evacuation and cleanse the external perianal area several times daily with moist boric acid cotton sponges. Careful postoperative observation cannot be too strongly urged. It must be remembered that wounds about the anal canal are potentially infectious. Sinus infection abscesses ulcers bridging and contracture are all complications that can be avoided by diligent care. Bowel lubrication is reduced as rapidly as possible. The passage of formed stools as early as it is comfortable

to the patient is desirable for their dilating effect upon the anal canal

Postoperative Care of the Bladder—Reflex urinary symptoms associated with painful rectal lesions are well known. This complication should be anticipated in all rectal surgery. Fluid intake is encouraged in the immediate postoperative period. The patient is asked to attempt to void six hours after surgery rather than to await distention. Male patients may be permitted to stand, females to kneel using a small basin. If the patient is unable to void, he is catheterized before distention becomes severe. Usually catheterization will not be necessary more than once or twice.

The wedge shaped operation as described is the most universally satisfactory and in general will give excellent results in the majority of cases. Failure of the operation is most likely to occur in those cases with an associated pathologic process at the pectinate line such as hypertrophic papillae. These sometimes become quite large and prolapse into the anal canal during defecation. Varicosities above and on either or both sides of the fissure also interfere with healing following this type of operation. In these cases the method of excision as described by Buie is more satisfactory than the wedge operation. This operation permits removal of a greater amount of tissue and thus also the associated disease. Healing is surprisingly rapid and function is good.

Buie's Operation

Technic—After a careful survey of the extent of the pathologic process and after decision has been made as to the amount of tissue to be removed, the field is exposed by a suitable speculum or retractor.

First an incision is made through the skin of the anal margin at right angles to the external sphincter fiber at the junction of the lateral and posterior quadrants of the anus on either side. These points are not always the same and one should be guided by the necessity of removal of tags or varicosities in conjunction with the remainder of the diseased tissue in order to secure a smooth outlet. One may go so far as to make the incision at the middle on both sides and excise the entire posterior half of

the anus if necessary. The external incision is begun in the margin of the anus and connecting the outer ends of the lateral incisions forms a curve posterior to the anus which is about 3 cm from the anal margin at its furthest point (Fig 68 c 1). The inner extremity of these incisions is carried just through the pectinate line so that another incision will cut across the mucosa just above that margin (Fig 68 c, 2). This whole area with the fissure marginal varicosity and hypertrophic papillae is dissected out down to the external sphincter leaving a denuded area and exposing the external sphincter.

A continuous suture is started at either end of the wound laterally and is carried across to the other side in order to bring the free edge of the mucous membrane into the central portion of the external sphincter muscle. In some instances in which the external sphincter is greatly hypertrophied it is advisable to cut through about half of the muscle fibers. A Lembert type of suture should be used in suturing the mucous membrane into the muscle because it turns in the margin of the cut mucosa against the muscle fiber in such a way as to prevent all possibility of bleeding. * The Lembert type suture has been replaced with fine interrupted sutures as shown in Figure 68 c 3 in this clinic. This gives better drainage and interferes less with the circulation of the flap. A splint dressing is applied.

HEMORRHOIDS

Hemorrhoids comprise about 40 per cent of all rectal ailments. Most people are affected to some degree at some time during their lives. Hemorrhoids are varicose tumors involving the internal or external hemorrhoidal plexus or both. For convenience they may be classified as internal, external and internal external (mixed) hemorrhoids. To the lay person they are piles and he often so labels all rectal conditions adding a symptomatic description that is bleeding piles itching piles burning piles blind piles and so on.

PATHOGENESIS—The pathogenesis of hemorrhoids may well be considered before attempting treatment. The superior hemorrhoidal vein which extends from the splenic to the internal hemorrhoidal plexus is devoid of valvular structure. This is a most important anatomical fact accounting for the

formation of varicosities of the anorectal area. Portal stasis, intra-abdominal tension and sedentary habits are exciting factors. Early in its formation an internal hemorrhoidal mass consists of many dilated small veins arising from the hemorrhoidal plexus held together by loose areolar structures located submucously just above the anorectal line and covered entirely by mucosa. As time goes on it becomes larger and begins to prolapse on defecation, returning of itself after the act is completed. The traction thus produced in the presence of the dilated veins tends to strip the lining of the anal canal away from the pecten and to dislocate the mucocutaneous junction downward. As a result of this dislocation and stasis the perianal skin becomes edematous and thickened and forms in folds commensurate with the location of the internal mass. These folds are not true hemorrhoids but rather skin tags (cutaneous hemorrhoids). In time the veins of the external plexus may become varicosed producing the true mixed hemorrhoids.

Uncomplicated hemorrhoids are relatively free from pain. When pain occurs some complicating factor has arisen such as thrombosis, ulceration, strangulation or fissure formation. The patient then experiences his attack of piles.

Degenerative changes are constantly taking place as a result of the friction of the constantly recurring prolapse, trauma from hard stools, ulceration with low grade infection and thrombosis occurring with or without strangulation producing destruction of some of the varicosities as well as fibrosis of the supporting areolar structure. This process of degeneration may be extensive enough to affect the spontaneous remission of the hemorrhoidal mass or it may be converted from a soft hyaline vascular mass to a more fibrous firm structure so called fleshy pile.

If this process is kept in mind the incidence of recurrence of hemorrhoids following operation will be more readily understood. Amputation of the hemorrhoidal mass does not correct the hydrostatic pressure exerted upon the plexus through the superior hemorrhoidal vein. This fact is so well appreciated by the surgeon dealing with varicosities of the leg but is often forgotten by him when dealing with varicosities

of the hemorrhoidal area. Recurrences are much more common following operation upon young persons whose hemorrhoids are likewise young, soft, vascular and perhaps not fully developed than the patient past middle life with more degenerative hemorrhoids.

Why varicosities tend to develop in more or less isolated areas within the hemorrhoidal plexus is not easily explained. The fact remains however that there are present usually two most commonly three distinct masses more rarely one or four. They tend to become more or less pedunculated and lend themselves to basal amputation. Occasionally however there occurs diffuse bulging of the plexus sometimes involving one side and occasionally the entire circumference, associated with more or less prolapse of the mucous membrane. It is this type that is best treated by a more radical procedure such as the modified Whitehead operation.

HEMORRHOIDECTOMY

The requirements of surgical treatment of hemorrhoids are removal of all varicosities, removal of excessive skin and mucous membrane, restoration of normal contour of the anal canal and preservation of normal function of the anorectal mechanism. Hemorrhoidectomy is a plastic operation performed in a potentially infected field. To meet these requirements many types of operation have been devised by many surgeons but the most useful procedures may be listed as *simple ligature with excision, clamp and suture, clamp and cautery*, and amputation or *modified Whitehead operation*.

Any surgeon who performs many hemorrhoidectomies will soon develop a preference for one or more of these operations; he will then devise his own technic in performing it and probably modify it from time to time as his experience dictates.

The *selection of operative method* is a far more important consideration than the technic, and depends upon the type, distribution and size of the hemorrhoids. It is my custom to use either clamp and cautery or simple ligature upon small hemorrhoids; on larger ones I prefer the suture ligature method and on still more extensive ones with marked pro-

lapse and skin redundancy I use the modified Whitehead. The requirement of any one of these procedures is the removal of all varicosities excess mucous membrane and skin thus restoring the normal contour and function of the ano rectal mechanism.

After anesthesia is given and exposure effected the field is studied and the complete operation planned before operation is begun. There may be a number of hemorrhoidal masses to be amputated frequently two hemorrhoids will coalesce and a decision must be made as to whether they should be treated individually or as one large mass. The amount of skin to be removed and the resultant condition of the anal canal are points to be considered. We frequently employ ligature clamp and suture on different masses in the same case. Cases are not infrequently encountered which show pedunculated hemorrhoids suitable to ligation on one side and on the other side a diffuse mass of varicosities with marked prolapse and redundant skin for which amputation or modified Whitehead technic is the treatment of choice.

✓ Ligature Operation

✓ This operation is suitable for *internal* and *small internal external hemorrhoids*. Anesthesia, division and exposure are carried out as described previously. The apex of the internal portion of the hemorrhoid is gripped with a Kocher forceps. Sufficient traction is made to have a tenting effect upon the mass. Then as it is lifted away from its anorectal bed with curved scissors a V incision is made through the skin just through the pectinate line (Fig 69 a 1). One must keep the scissors tip pointed towards the apex of the tented pile in making this incision otherwise too much of the anal canal may be resected. The excess tissue if any is present may be trimmed off after completion of the operation when the proper amount to prevent overhanging and looseness can be better judged. A No. 1 plain catgut ligature is now passed through the base of the pile just above the pectinate line taking care to place it so that accurate approximation of the line will be effected upon tying (Fig 69 a 2). One knot is now placed further traction is made downward and outward and

the ligature is passed through the upper pole of the mass (Fig 69 a, 3) This includes only mucosa and is done to prevent

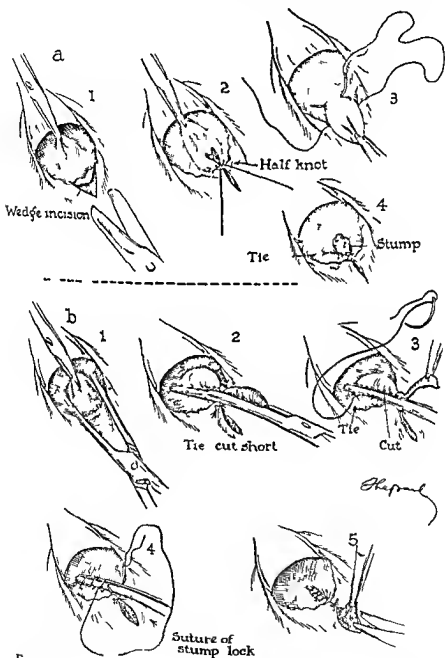


Fig 69—Hemorrhoidectomy a Simple ligation b, Clamp and suture downward slipping of the ligature which is now drawn taut and tied with three simple knots The mass is now amputated

with scissors leaving sufficient stump external to the ligature to avoid retraction (Fig 69 a, 4) Amputation is done before cutting the ligature it serves as a traction while making the amputation and should not be cut until the stump has been allowed to retract to its internal position If no bleeding of the stump occurs the ligature is cut long the skin edges are trimmed at the end of operation after all hemorrhoids have been removed

Clamp and Suture Technic

After adequate exposure and identification of the hemorrhoidal masses for resection the Pennington clamps are removed A Sims retractor is now inserted and traction maintained opposite the hemorrhoid selected for removal The apex of the hemorrhoid is grasped with a Kocher forceps and the mass pulled outward and away from the anal wall in a tenting effect A curved 6 inch forceps pointing in the long axis of the anal canal is placed across the entire mass (Fig 69 b 1) to include all skin and mucosa estimated for removal It is closed lightly (one or two notches) With a scalpel the skin is now incised keeping the cutting edge close to the forceps This incision extends up to and just through the mucocutaneous junction A suture of No 0 chromic catgut on a curved noncutting needle is placed through the edges of the mucocutaneous junction just below the crushing forceps This suture when tied accurately approximates the mucocutaneous junction (Fig 69 b 2) Traction is now made on the Kocher forceps applied to the apex of the hemorrhoidal mass so that the skin portion is pulled through the forceps The forceps is now closed completely so as to have a crushing effect upon the internal portion of the hemorrhoid The assistant holds and rotates this forceps into the long axis of the rectum and the operator by means of small Mayo dissecting scissors and tissue forceps dissects out the veins of the external plexus through the skin incision All frank bleeders are carefully ligated with plain No 00 catgut

A No 0 chromic catgut ligature on a curved noncutting needle is now carried through the upper pole of the internal hemorrhoid below the clamp and tied above it The mass is

then amputated external to the clamp (Fig 69 b, 3) It is important to place the suture ligature on the upper pole before amputating the hemorrhoidal mass in order to avoid slipping of the stump through the clamp which makes exposure and suture very difficult owing to retraction and bleeding Two or three loops are now passed through the base of the hemorrhoid and over the clamp in lock fashion the last one being placed near the mucocutaneous line (Fig 69 b, 4) The clamp is now removed The suture is drawn tight one simple stitch is taken at the mucocutaneous line and the suture tied The subcutaneous bleeding points if any have been overlooked are carefully picked up and ligated with No 00 cat gut The skin is not sutured It is left open to permit drainage

After completion of the entire operation any overhanging or ragged skin edges are trimmed away so that the edges fall together smoothly (Fig 69 b, 5) The rectum is cleansed of blood and a splint dressing is applied

This operation is satisfactory for most cases of *combined internal and external hemorrhoids* when they occur in distinct masses or tend to be pedunculated However one frequently encounters a case in which there is marked prolapse with large varicosities involving the entire side This type of operation may not meet the requirements in such an instance and an amputation type of procedure selected

Modified Whitehead Operation

Often a case is seen in which the hemorrhoids are *extremely large* with extensive *prolapse* and *dislocation of the lining* of the entire anal canal Usually no distinct hemorrhoidal masses can be distinguished This type of case demands a more radical procedure and it is here that a modified Whitehead procedure if properly done will give a better end result

Whitehead originally made a circular incision through the skin at the outer border of the sphincter body external to the anal orifice The entire lining of the anal canal mucosa and veins were dissected out This tube was then imputated well above the pectinate line and the mucosa advanced outward and sutured to the skin When healing occurred the anal canal was then lined with mucous membrane which when

thus exposed became inflamed. Then the patient was annoyed by constant mucus leakage. In the event that healing of the suture line failed stricture was certain to follow owing to fibrous constricture.

Such stricture formation can be avoided by careful restoration of the mucocutaneous juncture to its normal level at the upper border of the sphincter body. This is the main objective of the modified Whitehead operation.

In this modified procedure the field is exposed in the usual manner. An Allis forceps is placed on the pectinate line in the anterior and posterior midline and traction is made. A Sims retractor is inserted to protect the opposite side. An incision is made just distal to the pectinate line (Fig 70 1). The edges of the incision are grasped with two Allis forceps on either side and a dissection of the external veins is begun. Care is exercised to preserve the subcutaneous fascia and not to buttonhole the skin flap. When the outer border of the venous mass is reached it is reflected upward and dissected from the sphincter body, taking care not to injure these structures. This dissection extends from the anterior to the posterior midline and upward to the upper border of the sphincter body (Fig 70 2).

At this time it is important to make a careful estimate of the amount of mucosa to be amputated so that when the skin margin is replaced within the anal canal the slack will be removed without too much tension on the suture line. When this is determined a crushing clamp is placed across the mucosa. The hemorrhoidal mass is now amputated external to the clamp (Fig 70 3). A mattress suture of chromic No. 00 catgut is now carefully placed at the anterior angle of the incision in such a fashion as to draw the mucosa under the skin. A similar suture is placed posteriorly (Fig 70 4). The crushing clamp is now removed and the two sutures are drawn up and tied left long and used as tractors (shown cut short in Fig 70 5). The Allis forceps at the anterior and posterior angles are now removed.

The mucous membrane is next grasped with an Allis forceps midway between the two sutures and repair of the newly formed pectinate line is begun by a mattress suture of

No 00 catgut through the mucosa into the sphincter muscle on either side of the Allis clamp (Fig 70, 5) The clamp is removed and all bleeding points are ligated A running

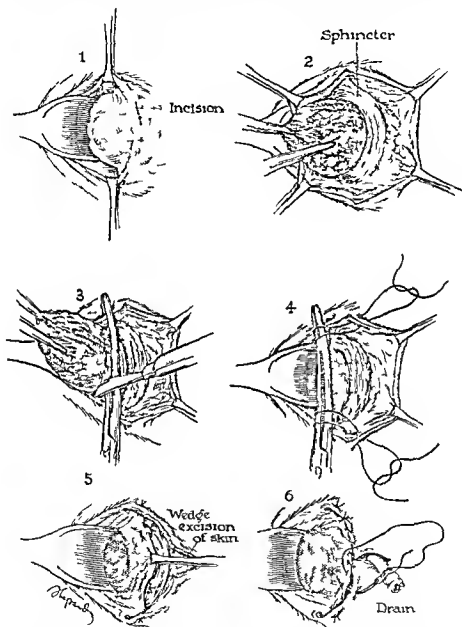


Fig 70—Hemorrhoidectomy Modified Whitehead operation

Lembert type suture unites the mucosa to the skin edge from anterior to posterior so that both raw edges are turned in with the skin overlying the mucosa (Fig 70 6) It is important

to maintain traction in the opposite direction upon the first two sutures while this is being done otherwise there is danger of narrowing the anal canal. A V shaped section usually removes any excessive skin midway between the anterior and posterior lines (Fig 70 f). One or two sutures of No. 000 catgut are placed in the incision and a gutta serena drain is inserted through the incision. The same procedure is carried out on both sides.

Clamp and Cautery Method

The technic of this procedure is exactly similar to the clamp and suture method except that some type of crushing clamp designed to protect the tissue from the cautery point is applied instead of the usual curved crushing clamp. The hemorrhoid is amputated external to the clamp leaving enough tissue to procure a good eschar from the cautery. The surrounding tissues are next protected by moist gauze and the protruding stump is slowly cauterized keeping the cautery point at about cherry red heat thus producing a slow coagulation. After removing the wet gauze simple ligatures may be placed at the upper and lower poles of the base of the hemorrhoid. These reduce the tension upon the eschar and should be employed if the mass is large. The head of the clamp containing the hemorrhoid stump is now returned to a position within the anal canal before it is released. In removing the remaining hemorrhoid care should be exercised not to open up these eschars by manipulation of instruments or extensive dilatation of the anal canal.

Axioms for Hemorrhoidectomy

1 Successful surgery depends upon *good anesthesia sufficient slow dilation proper exposure and proper selection of procedure*

2 It is the *irritations* that are productive of symptoms. Complete removal is necessary.

3 Resection of *too much* anal skin is the cause of most contractures and strictures. It is better to leave too much than too little since it can always be removed by simple procedure later if necessary.

- 4 The *continuity of the pectinate line* must be restored
- 5 The *crushing clamp* for suture or cautery must always be placed in the long axis of the anal canal The clamp for the suture method is not placed as deep as for cautery Allowance for further constriction of the suture under the clamp must be made
- 6 All *bleeding* must be controlled Never depend upon pressure dressings to control bleeding All stumps and suture lines should be finally inspected at the end of operation
- 7 The anal canal *should never be constricted* Suture lines must not have tension upon them

EXTERNAL THROMBOSED HEMORRHOIDS

External hemorrhoids *per se* seldom require operation The one exception is the case with thrombosis Usually the patient suffering from external thrombosed hemorrhoids does not seek help until he has weathered the storm for two or three days as a matter of fact he usually reports to the surgeon when sufficient relief permits him to visit the office In such instances it is probably just as well to treat the condition conservatively The patient has passed his most uncomfortable period and surgical intervention at this time will only serve to reactivate his symptoms If consulted within the first twenty-four hours after onset the patient will be spared much suffering and disability depending upon the size of the thrombosis by simple excision of the clot The thrombosis usually occurs at the external margin of the anal canal It is frequently multiple Simple infiltration of the skin margin with 0.5 per cent novocain and excision of the protruding mass with its redundant skin is sufficient It is best to place a very fine plain catgut mattress suture at the upper angle of the excised area to control subsequent bleeding

FISTULA IN ANO

An anorectal fistula is a suppurating communication between the skin and the anorectal canal Such a tract having an internal and external opening is a *complete* fistula, having only one opening it is an *incomplete* fistula An incomplete fistula with its opening within the anorectal canal is a *blind*

internal fistula or an *anorectal sinus*. An incomplete fistula having only an external opening is an *external fistula*.

ETIOLOGY—*Abscess formation* is a precursor of fistula. Perforation of the abscess either spontaneously or surgically completes the fistulous formation. The course of this suppurating fistulous tract will therefore depend on the origin of the infection, the location of the abscess and its point of perforation.

The point of origin of the infectious process resulting in abscess formation may be either (1) *intrinsic* that is from within the anorectal canal—from ulceration, cryptitis, fissure in ano, traumatic perforation as by fish bones, enema tips and so forth—or (2) *extrinsic* from suppurating external hemorrhoids, breaking down of lymphatic glands in the retrorectal space or ischiorectal fossae, pelvic infections with supralelevator abscess, periurethral infections and osteomyelitis of the bony pelvis and hip joint.

Abscesses about the anorectal area may be considered according to their locations as (1) marginal or subcutaneous, (2) submucous and (3) submucocutaneous (dumb bell), (4) ischiorectal, (5) retrorectal, (6) supralelevator or pararectal. It must be appreciated that abscesses of the retrorectal space, supralelevator, pararectal space and the ischiorectal fossae may originate from infection outside the rectum and then perforate into the anorectal canal. The internal opening then becomes the exit for the abscess. With the exception of the supralelevator abscess the mechanism of formation is in the opposite direction that is from within outwards. (See Fig. 71 a.)

PATHOGENESIS—Any condition which produces a dissolution of the lining of the anorectal canal may result in fistula formation. These processes may be inflammatory as cryptitis, ulcerated, thrombosed hemorrhoids and ulcerative proctitis or traumatic such as puncture wounds produced by foreign bodies or traumatic fissure in ano. The most common sequence of events in the development of a fistula is as follows. The passage of a formed hard stool results in tearing of the anal lining which as was pointed out in the discussion of fissure in ano most frequently occurs in the posterior or anterior midline. Infection ensues between the anorectal lining and the anal sphincter. It burrows either outward toward the external

anal margin where an abscess develops (marginal abscess) or upwards under the mucosa resulting in a submucosal abscess. Occasionally both are present thus forming a *dumb bell abscess*. As the infection burrows outward it may pass outward through the sphincter body and involve the posterior triangular space. From here it may split out into one ischiorectal fossa or both. If both fossae are involved, the condition is known as a *horseshoe fistula*. When the ischiorectal space is involved the infection may extend throughout the space with little resistance because of the loose fatty tissue present. This leads to *multiple external openings* because the suppurating process points in different locations with each subsequent abscess formation. Usually the patient will seek surgical relief if spontaneous rupture does not occur within a few days. The surgeon will of course open the abscess externally through the skin. Occasionally however, an abscess high in the ischiorectal space may burrow through the levator muscle and a *supralevator pararectal abscess* results which may in turn open through the rectal wall above the sphincter body. If this happens there will be a suppurative tract completely encircling the body of the sphincter having an internal opening in the anal canal, one or more external openings in the ischiorectal space and a second internal opening above the sphincter. These cases tax the skill and judgment of the surgeon.

Fistulous communications with hollow visci other than the rectum may have their external openings somewhere about the perineum as well as into the rectum. They are complicated fistulas as for example rectovaginal, rectovesical and urethrorectal fistulas. They must not be confused with fistula in ano and care must be taken not to convert a perineal sinus from some such viscus into a rectal fistula by persistent searching for an anorectal opening at the time of operation. Careful diagnostic study before operation should eliminate this possibility but if one is in doubt it is better to discontinue the operation than to open into the anorectal canal through what appears to be a possible internal opening.

Careful examination of the entire anorectal canal and pelvic structures in all cases of fistula cannot be too strongly stressed. It is well to have in mind a third dimension picture of the en-

ture fistulous tract before attempting operation. If one keeps in mind these pathways of infection and takes a careful history and makes a complete examination the entire picture can usually be visualized very accurately. A diagrammatic scheme which is helpful in mentally visualizing these pathways is that of Salmon who states: external fistula openings anterior to a line bisecting the anus horizontally and within 5 cm. of the anal margin will have their internal openings radially opposite the external. All other external openings will have their internal openings in the posterior midline. This is true in 85 per cent of cases of fistula in ano.

TREATMENT

The treatment of fistula is essentially surgical. Prophylactic surgery is all important. To correct fissure in ano early is to prevent fistula formation. Likewise treatment of any ulcerative process within the anal canal with early and adequate incision of perianal and rectal abscesses while probably not preventing fistula lessens the destruction from subsequent spreading of the infection.

The time for fistulectomy is also important. In the cases of marginal and submucous abscesses the entire tract may be safely opened at the time of incision of the abscess; thus one procedure will effect a complete cure. If however the tract is deep and more extensive and suppuration is extensive it is far better to institute adequate drainage and to elect surgery at a time when suppuration is minimal.

Repair of Fistula

Anesthesia—Sacrococcal or low spinal anesthesia is preferable. Infiltration is not satisfactory except for the simple mucocutaneous tract because of the difficulty of administration and the danger of dissemination of infection.

Position—Lithotomy or prone jack knife.

Divulsion—Unless there is marked constriction of the anus very little dilatation is done until the internal opening has been located. To the occasional operator this divulsion is usually the most difficult part of the procedure and a definite plan should be followed.

Search for the Internal Opening—In exploring and operating upon the tract it is best to follow the source that the infection has traveled that is from within outward. Only when this proves impossible should one proceed from without.

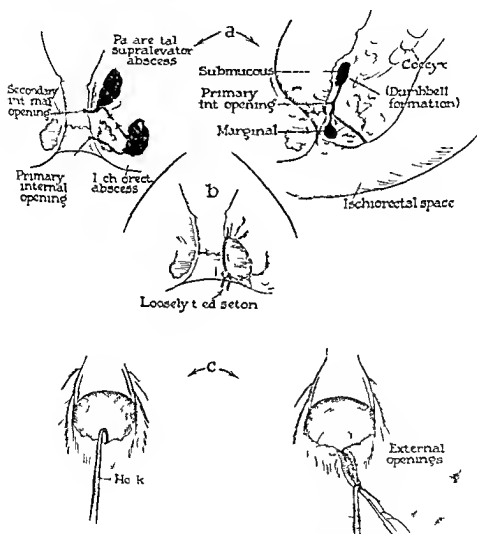


Fig 1—*a* Mechanism of fistula formation *b* Seton ligature *c* Tract being laid open

inward. Many surgeons inject colored solution through the external opening in order to locate the internal opening and identify the tract. This is seldom necessary and usually undesirable because the tissues are so badly stained that it makes it difficult to distinguish the normal from the inflammatory

tissue. If one keeps in mind that the fistula has only one primary opening and one or more secondary openings and that the primary opening is the source of the infection it will make the surgical approach much easier. Salmon's law becomes of value in searching for the internal opening.

The pectinate line is exposed and a careful search for the primary opening is made with a curved probe or crypt hook (Fig 71 c). Usually a definite sinus is easily found; sometimes pus will be seen welling up through it. Sometimes a small granuloma surrounds it or induration can be felt about the base of a papilla. An old fissure may be present and if it is the internal opening will usually be found in its bed. Occasionally, however, one is unable to demonstrate an internal opening and a so-called external fistula may exist. This may be due to a subsequent closing of the internal opening after infection has burrowed through and the external sinus continually draining an old abscess cavity permits the internal opening to close. In such cases approach from without may be justified and a section of the lining of the anal canal may be removed at the point of suspected internal opening.

Exposure of the Tract—When the internal opening is found the curved probe is passed into the tract and the body of the sphincter external to the tract, if there be any, is divided at right angles to its fibers (Fig 71 c). The amount to be divided is variable but usually only a portion of the external fibers will be divided. At this time it is well to investigate the mucous membrane above the internal opening for if burrowing has continued upward as well as downward it may be necessary to divide slightly more of the sphincter in order to prevent adequate drainage of a submucous pocket. The fistulous tract with all of its branches is now laid open and all overhanging edges are trimmed away. The tract bed is next carefully inspected for sinuses extending deep into the ischiorectal space. If any are found they are next opened and explored.

Treatment of the Tract—After all tracts are opened one may then decide whether or not to dissect out the fibrous tract. This will depend upon the thickness of the tract, its extent and the subsequent gaping and resulting deformity.

from the excision. In general, healing will progress more rapidly and with less suppuration if the tract can be excised. If it is left healing may be facilitated by curetting out as much of the indolent tissue as possible or by light cauterization of the tract wall. All bleeding points are picked up and ligated with fine catgut and the wound is sponged dry, powdered with sulfathiazole, strips of vaseline gauze are laid in the tract and warm moist boric acid dressings are applied. Occasionally the outer limb of the fistulous tract may be sutured after the fibrous tract is removed. This is never done near the anal margin where pocketing may result.

Postoperative Care—The packing is removed on the second or third day, the wounds are inspected, cleansed, repowdered and packed very lightly if at all. The wound must be watched constantly to prevent bridging of the skin margins. Neglect of this postoperative care is one of the most common causes of failure to cure fistula. Especially is this true at the anal margin. From time to time it may be necessary to cauterize granulation tissue with silver nitrate or to reopen small pockets that may be forming because of bridging of the skin. Careful cleansing by the patient after bowel movement is important. This is best done by sitz baths and later by the use of a small spray which can be attached to the faucet of the bath tub. The time required for complete healing will depend on many factors but the average should be from two to eight weeks.

Modifications of Procedure—Conditions may exist which make it advisable to vary this procedure. The tract may run deep within the body of the sphincter thus necessitating its division. If this is true it is a good procedure to dissect out the tract from its external opening downward to the sphincter body then to pass an unabsorbable seton through the tract and to tie it loosely about the sphincter external to the tract (Fig. 71-6). This seton permits drainage and prevents partial closure of the tract. It also aids in relocating the tract when the second stage is carried out. This is done after the dissected portion of the tract is granulated and contracted. It is then a simple matter to divide the sphincter down to the seton at right angles to its fibers by means of infiltration anesthesia.

Complete Division of the Sphincter—The sphincter may be divided completely in the posterior or anterior midline and satisfactory control will be restored provided healing is complete and without suppuration. If not a subsequent plastic procedure and the bringing together of the sphincter muscle by raising its cutaneous flap is not difficult. The result will be much less a handicap to the patient than if the fistula is allowed to persist. Nearly all lateral fistulas are superficial and will not involve the sphincter. Anterior and posterior horseshoe fistula will most commonly be benefited by the seton. The occasional internal opening above the mucocutaneous line may present a problem for considerable study as to how it can best be converted so that the sphincter may be divided in the anterior or posterior midline.

Failure of Fistula Surgery—Failure is usually due to inadequate surgical care. Its causes consist of (1) failure to find an opening through the internal opening (2) failure to open all collateral tracts (3) inadequate excision of skin edges (4) careless or inexperienced postoperative care resulting in sealing of the skin edges poor drainage and reformation of the abscess (5) constitutional diseases such as tuberculosis syphilis or diabetes (6) unrecognized complicated fistula such as rectovaginal rectovesical or urethral.

Tuberculous Fistula—In true fistula in ano tuberculosis is a secondary invader of a previously existing fistula. It will usually not be diagnosed except by guinea pig inoculations with the granulations of the fistulous tract. It may be suspected by the marked fibrous and indolent character of the tissues with comparatively little suppuration. A diagnosis of tuberculosis of itself is not a contraindication to surgery. If the patient's general condition warrants surgical intervention and there is not an open pulmonary lesion or an ulcerative process of the gastro intestinal tract healing although slow will occur provided excision is adequate and the usual post operative care is given.

TREATMENT OF FRACTURES OF THE OS CALCIS PRESENTATION OF A NEW METHOD*

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and

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FRACTURES of the os calcis present unusually difficult problems in reduction and restoration of function. The importance of these problems is growing with the increase in the number of such injuries not only in combat but in men in training on the athletic field and even on liberty. Airplane crashes, parachute jumping and explosions aboard ship are augmenting the incidence of these fractures. Explosions of mines or torpedoes against a ship lift the men off the deck and cause an injury in landing similar to that of a fall. Fractures of the os calcis are also sustained from deck vibrations caused by explosions or near misses. With this material increase in the number of os calcis fractures it becomes the duty of the medical officers of the armed services to make every possible effort to expedite the return of these casualties to duty.

The first real scientific approach to a solution of the problems offered by this difficult fracture is credited to Lorenz Bohler¹ and his associates Vidal, Schneck and Ehalt, whose work became the basis of our present therapy. The principles as outlined by Bohler are generally well accepted and fulfill the basic requirements of fracture treatment in general as attested by Hey Groves and Watson Jones. However the application of these principles in the management of fractures of the os calcis is often difficult and impracticable, espe-

The opinions or assertions contained herein are the private ones of the writers and are not to be construed as official or reflecting the views of the Naval Department or the naval service at large.

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cially on board ship and in the field hospital where access to special reduction frames and fracture equipment is not available

In the Bohler method after proper reduction of the fractured os calcis the position is maintained either by continuous traction or by transfixation in plaster with Steinmann pins through the os calcis and tibia. In either case it requires the proper application of the nonpadded plaster cast which even in experienced hands is a difficult procedure and fraught with danger and serious complications when performed by the casual operator. Treatment by continuous traction offers obvious objections on board ship while in field hospitals it is often impracticable. Treatment by transfixation in plaster is objectionable not only because of the difficulty in its application but because (1) plaster is not a rigid immobilizing agent especially where slight pin seepage is present (2) plaster transfixation does not allow for secondary adjustments which to be made requires the removal of the cast and replacement on the reduction frame. This not only unnecessarily prolongs the primary operation when the initial reduction was unsatisfactory but adds to the morbidity where secondary adjustments are required.

) Kreuz suggested the application of the principle of the Strider fixation splint to a new splint to overcome these handicaps

A NEW APPROACH IN THE TREATMENT OF COMPRESSION AND COMMINUTED FRACTURES OF THE OS CALCIS

The exigencies of the service demand that we return casualties to duty as quickly as possible. The treatment cannot be too complex or require cumbersome and intricate equipment. The treatment must be universally adaptable to the average traumatic surgeon on board ship or in the field hospital as well as in the well organized base hospital. Although we agree with the advocates of delayed reduction in fractures of the os calcis which allows us eight days to get the patient to a base or shore hospital there will be times when the reduction must be performed on board ship or in a field hos-

pital The treatment must conform to the basic requirements governing the treatment of fractures in general

We have developed a method of approach to this complex problem of os calcis fractures in cooperation with Stader who designed an external reduction fixation splint (Fig 72, A) which we have used in nine cases at the United States Naval Hospital Philadelphia This apparatus permits not only *reduction* of the fracture but becomes the splint upon completion of the reduction No reduction frames or plaster are required The fixation is constant and rigid The integrity of the subastragaloid joint is constantly maintained The turn buckles permit controlled tangential traction in either valgus or varus The constantly controlled traction allows one to overextend and produce *sufficient space* into which the literally displaced fragments may be easily compressed, *often by hand*

Secondary adjustments may be made with ease and without sacrificing the position already obtained Active motion of the knee and toes and activity with crutches promotes earlier healing With constant rigid fixation there is no pain or discomfort, and the general well being of the patient is promoted

IMPORTANT ANATOMICAL CONSIDERATIONS

The spongy character of the os calcis with its thin outer cortex gives it a certain elasticity to withstand the stresses and strains of weight bearing Most of this weight is borne by the outer arch of the foot consisting of the os calcis cuboid and outer two metatarsals In running and jumping much of the jar is taken up by the so called 'spring ligament,' or inferior calcaneoscaphoid ligament which traverses the space between the sustentaculum tali of the os calcis and the inferior surface of the scaphoid thus reinforcing and protecting this important articulation

Lateral flexibility of the foot is necessary to allow one to walk on uneven surfaces and to absorb lateral thrusts on the foot as for accommodation to the roll of a ship This mobility is assured by the subastragaloid joint with its two important articulations one posterior between the bodies of the os calcis

and astragalus and the other anterior between the head of the astragalus and the sustentaculum tali

The posterior calcaneal articulation is large and rounded with its convexity upward the anterior is small and concave Between these two articulations is the strong interarticular ligament which binds the adjacent talus and calcaneus together and thereby helps to sustain the integrity of the subastragaloid joint space The ability to stand on one's toes depends upon the activity of the gastrocnemius muscle whose achilles tendon is inserted into the posterior surface of the tuberosity of the os calcis The upper surface of the tuberosity runs obliquely downward from the edge of the posterior subastragaloid articulation and lines drawn from this point anteriorly to the anterior rim of the anterior subastragaloid articulation and posteriorly over the superior surface of the tuberosity will bisect to form an angle of about 40 degrees This is the so called *tuber joint angle* of the os calcis so essential in the evaluation of the pathology as well as the proper treatment of os calcis fractures

IMPORTANT PATHOLOGICAL CONSIDERATIONS

Depending upon the anatomical integrity or viability of the bone itself the os calcis fracture may vary from simple isolated fracture lines without displacement to various degrees of compression and comminution in the most serious of which the os calcis may be literally smashed to pulp

In every fracture of the os calcis the two most important considerations are the degree of the disparity of the tuber joint angle and the extent of the involvement of the subastragaloid joint As a general rule the greater the disparity of the tuber joint angle the more extensive the compression and comminution and therefore the greater the encroachment upon the subastragaloid joint space

The line of longitudinal fracture usually passes through the posterior articulation with various degrees of lateral displacement of the lateral portion and there may be one or more perpendicular fracture lines running down through the inferior surface of the os calcis Normally the weight bearing lines of force pass through the medial side of the os calcis

and not through its center and in walking there is a tendency of pronation of the os calcis sometimes aggravated by the pull of the gastrocnemius especially in the flat foot

In fractures the inferior and lateral portions of the os calcis are generally displaced outward and upward. This lateral bulge can readily be felt under the external malleolus. Because of the upward displacement of the tuberosity the Achilles tendon is shortened and the tuber joint angle decreased. Depending upon the extent of comminution and transverse fracture lines there is a greater or lesser degree of shortening of the os calcis produced mainly by the action of the short muscles of the foot. The extent of shortening and compression can usually be discerned by palpating the medial surface of the os calcis and measuring the distance from the malleoli to the posterior inferior surface of the os calcis.

The normal concavity of the medial surface of the os calcis will be destroyed as well as the normal varus position of the heel. Further encroachment upon this concavity may also be produced by a medially displaced sustentaculum tali which may be fractured alone or in conjunction with severe comminuted fractures of the os calcis. Occasionally the calcaneocuboid joint may be involved usually by longitudinal fracture lines running into the joint. In severe fractures producing a displacement of the entire posterior articulation one should look for a concomitant displacement of the astragalonavicular joint the head of the astragalus being tipped forward and usually rotated.

THE DISABILITY IN BAD RESULTS

The chief complaints of the patient with a badly united fracture of the os calcis are pain, limitation of lateral motion and inability to run, jump or stand on the toes. Where fracture lines have extended into the subastragaloid joint causing hemorrhage and eventually fibrosis and irregularity of the articular cartilage the residual pain and disability are usually proportionate to the accuracy of the replacement of the displaced fragments and the *maintenance of adequate joint space during the process of healing*.

The normal subastragaloid joint space is large and well de-

fined so as to allow for its peculiar motion and the preservation of this space is important not only from the standpoint of proper functional restoration, but because the maintenance of this space during the reparative process permits better healing of the articular cartilage as well as the subchondral bone. The strong interosseous ligament will also heal more readily in its normal extended position with an adequately maintained joint space.

The body can usually accommodate itself painlessly to mild irregularities in the articular surface of the subastragaloid joint provided there is adequate joint space whereas with restriction of joint space there is usually pain regardless of the regularity of the joint. Secondary traumatic arthritic changes may develop regardless of any and all therapeutic procedures and may not appear for months or years after injury. Abnormal dorsiflexion of the foot and weakness and inability to stand on the toes are due to a lengthened heel cord as a result of improper reduction of the disparity of the tuber joint angle and upward displacement of the tuberosity.

Painful medial ligaments and traumatic pes planus in an otherwise well treated fracture of the os calcis are due in part to the alteration in the normal varus position of the os calcis in which the lines of force of the body are shifted more medialward on the os calcis producing a tendency to valgus of the hind foot. With this abnormal valgus or pronation of the hind foot the insertion of the achilles tendon is shifted laterally in relation to the weight bearing and the gastrocnemius tends to act as a pronator of the hind foot thus increasing the flat foot.

Another important factor producing pain after treatment for os calcis fractures is the *deminerlization* of the bones as a result of prolonged immobilization. We believe that this factor has not been sufficiently stressed. It has occurred to us that possibly we have been immobilizing our os calcis fractures too long. We have therefore been working on the principle of *minimal length of immobilization and early weight bearing*, to prevent the extensive osteoporosis or deminerlization which is general in os calcis fractures thereby decreasing the morbidity and painful disability from this cause.

THE DIAGNOSIS OF FRACTURES OF THE OS CALCIS

Proper x ray facilities may not always be available to the medical officer of the armed services, and he may be called upon in many instances to treat fractures of the os calcis without benefit of adequate x-ray films or their expert interpretation. It becomes necessary for him, therefore, to evaluate the case on hand by physical examination alone.

Any painful heel, whether traumatized directly by a fall or indirectly by the effects of an underwater explosion on board ship, should be regarded as a potential fracture of the os calcis. Local swelling and tenderness and pain on weight bearing are constant findings. When there is any appreciable widening and comminution, the diagnosis may often be made by observation alone.

It is well, if only one heel is involved, to compare the injured with the uninjured side. In doing so, the thumb is placed along the medial concave surface, and the second, third and fourth fingers on the lateral surface, and the following facts noted in each: (1) the width of the os calcis, (2) the contour of the medial concave surface of the os calcis, (3) the smoothness and regularity of the lateral surface, (4) the extent of bulge of the lateral surface and encroachment of the normal space under the external malleolus, (5) the amount of shortening and compression by noting the distances from the base of the heel in the cupped palm: the tip of the internal malleolus with the thumb and the tip of the external malleolus with the middle finger, (6) the degree of flattening or disparity of the tuber joint angle by the upward tilt of the tuberosity and flattening of the sole, (7) the extent of laxity of the achilles tendon by the abnormal dorsiflexion of the foot which may be easily determined under anesthesia.

When the proper x ray facilities and interpretations of films are available, a thorough study of the os calcis should include proper plantar, dorsal and lateral exposures, as well as views of the midtarsal joint. X ray views of the uninjured extremity should always be taken for comparison when possible, so as to have a concept of the patient's normal foot architecture except in cases of obvious abnormalities.

APPLICATION OF THE SPLINT IN THE TREATMENT OF COMPRESSION AND COMMINUTED FRACTURES OF THE OS CALCIS

The reduction may be performed immediately or delayed until the primary swelling has disappeared. Spinal anesthesia is the anesthesia of choice 75 to 100 mg of novocain being sufficient in the average case. Both legs are prepared so that the width of the normal os calcis may be ascertained during the operation to check the amount of compression to be used on the injured member.

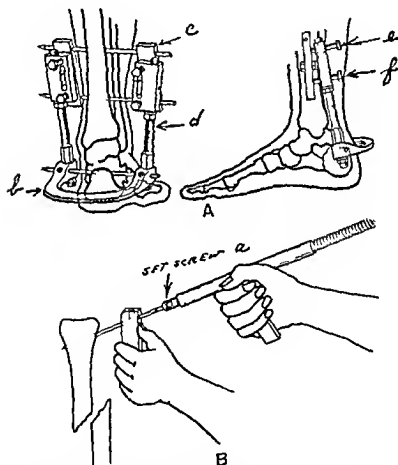


Fig. 72—A Os calcis reduction fixation splint (St. der) b U shaped horizontal bar c parallel bars d adjustable connecting bar e finger ring f g screws B Flexible shaft hand-operated drill

Insertion of the Pins

A stainless steel pin, $\frac{3}{16}$ inch in diameter and 6 inches long is placed in the chuck of the flexible shaft hand drill (Fig 72 B) and secured with the set screw (a). It is then inserted in the U shaped bar (b, Fig 72 A) and drilled transversely through the os calcis in its most *superior posterior* portion just at the insertion of the achilles tendon (Fig 73 A) emerging again through the U shaped bar on the opposite side (Fig 73, B). It is essential that this pin be inserted through the upper posterior tip of the tuberosity so that the traction force to reduce the disparity of the tuber joint angle and shortening is properly applied. In order to determine this exact location we have used a local anesthetic needle to guide the pin insertion. The insertion of the pins through the lower end of the tibia is greatly facilitated by means of the hand-operated flexible shaft drill which rotates the pins slowly and allows a free hand for the operator.

The second pin also $\frac{3}{16}$ inch in diameter and 6 inches long is now placed in the drill chuck passed through the pin bar (c) and drilled through the lower third of the tibia (Fig 73 C) about five fingerbreadths from the tip of the internal malleolus this pin bar being held parallel to the shaft of the tibia so that the pin will pass *transversely* through the shaft of the tibia and emerge on the opposite side through the corresponding pin bar. The third pin is now inserted through the lower channel of the pin bar passing through the tibia to engage the bar on the opposite side. The pins are then secured to the bars by means of the set screws (Fig 73 D).

The foot should be held in dorsiflexion during the insertion of the tibial pins to prevent equinus and undue skin tension.

Reduction of the Shortening and Disparity of the Tuber joint Angle and the Widening of the Fractured Bone

The turnbuckle lateral bars with their adjusting mechanisms (d) are now connected with the pin bars and tightened by hand. By properly adjusting screws (e) and (f) the desired tangent for traction is obtained (Fig 73 E).

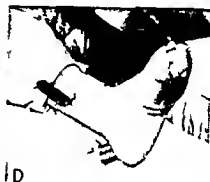
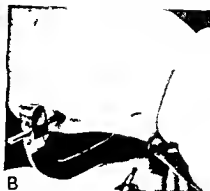


Fig 73.—*A* Pin placed in U shaped bar and then inserted through upper posterior aspect of tuberosity of os calcis *B* Pin engaging U shaped bar on opposite side. Pin locked in bar by set screw *C* Drilling pins through lower end of tibia through lateral pin bars *D* Pin bars in place pins locked in bars Ready for application of adjusting turnbuckle bars *E* Adjusting screws for desired tangential traction *F* Activating turnbuckles for traction

Reduction of the shortening and disparity of the tuber joint angle is now obtained by activating the turnbuckle. By means of wrenches the operator simultaneously turns both turnbuckles until the desired amount of extension is accomplished (Fig 73, F). If possible, a cheel x ray is now obtained, and when the shortening and disparity of the essential angle have been reduced, the *widening* is then reduced by means of compression with the os calcis clamp. The os calcis is compressed until the measured distance is reached which is usually about $1\frac{1}{2}$ inches, whereupon the clamp is immediately removed.

If the preliminary reduction of the shortening and disparity of the essential angle was accurate the compressed fragments will remain in place because adequate space had been prepared for them and the splint rigidly maintains the reduction during and after the compression. We have been impressed with the lack of force required to compress an os calcis fracture in this splint. The laterally displaced fragments may sometimes be replaced by hand, thus preventing unnecessary damage to the contiguous soft tissues. If undue force is necessary to reduce the widening then the shortening and disparity of the essential angle has probably not been adequately reduced because as in all fractures the shortening must be corrected before the lateral displacement can be reduced.

After care

Final x rays are now taken and if further adjustments are required which is unusual they may be performed without disrupting the reduction already obtained. Alcohol dressings are placed about the pin sites for the first twenty four hours, after which no dressings are used. Restoration of function by means of active exercises of the knee and toes is begun immediately, and the patient is allowed up on crutches as he desires.

Period of Immobilization

Because we desire to limit the period of immobilization to the minimum we have arbitrarily set six weeks for the

cases of moderate displacement and eight weeks for those of marked displacement. This period is followed by three weeks of physiotherapy without weight bearing. For the next three weeks guarded weight bearing is permitted, the patient being discharged from treatment in three to four months. Although our first five cases have responded to this abbreviated period of immobilization, all with freely movable painless subastragaloid joints, we realize that we may be required to prolong the treatment in the severely comminuted types.

End Results

The final appraisal of end results must be withheld for at least one year. The possibility of the development within that time of traumatic arthritis as a result of the comparatively early full weight bearing (four months) must be considered. A careful follow up is being maintained to determine the necessity for modification of this procedure as regards the period of immobilization as well as the institution of weight bearing.

REPORTS OF COMPLETED CASES

CASE I (Figs 74-75) — J. P., aged twenty-seven years, sustained a fracture of the left os calcis by a fall of 15 feet eighteen hours before admission on March 20, 1942. X-rays showed moderate comminution and disparity of the tuber joint angle. Reduction was performed on March 24, 1942, by means of the modified reduction fixation splint. The splint was removed in six weeks, followed by physiotherapy for three weeks, then gradual weight bearing. Limp and limitation of dorsiflexion of the ankle persisted for six weeks. Free subastragaloid joint motion was present. The patient was discharged on August 15, 1942, to full duty.

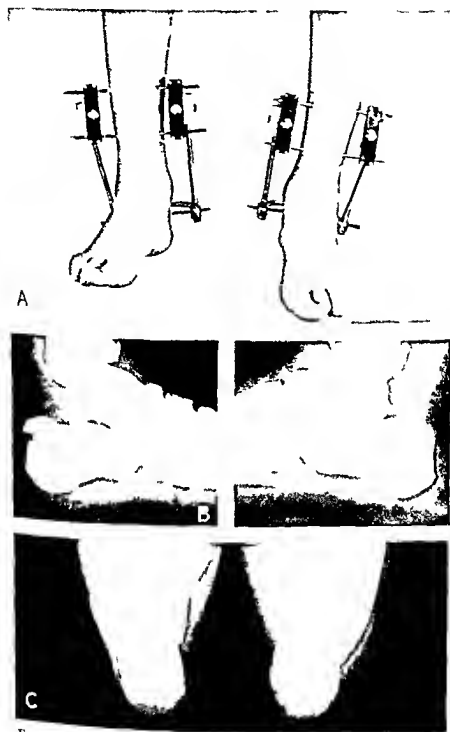


Fig 74 (Case I J P) —A Bilateral severely compressed fractures of os calcis with splints in place B Lateral x ray views before reduction C Plantar dorsal views before reduction

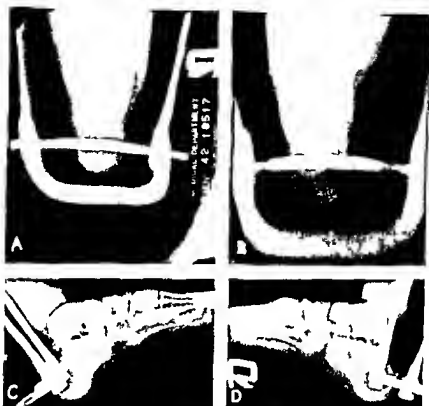


Fig 75 (Case I J P cont med) —A Plantar dorsal x ray view after reduction right B Plantar dorsal view after reduction left C Lateral view after reduction

CASE II (Fig 76) —S B aged fifty one years fell 8 feet and landed on his heels sustaining a moderate comminuted and compressed fracture of the right os calcis, and a Pott's fracture of the left ankle. He was admitted on June 4 1942 the day of accident. Reduction was made on June 9 and the splint removed July 21. Guarded weight bearing was begun on August 12. The patient was discharged from the hospital on August 15 1942 with excellent subastragaloid motion and minimal symptoms on crutches. Full weight bearing without crutches began on September 9. He returned to work as a Navy Yard employee on October 15 1942.

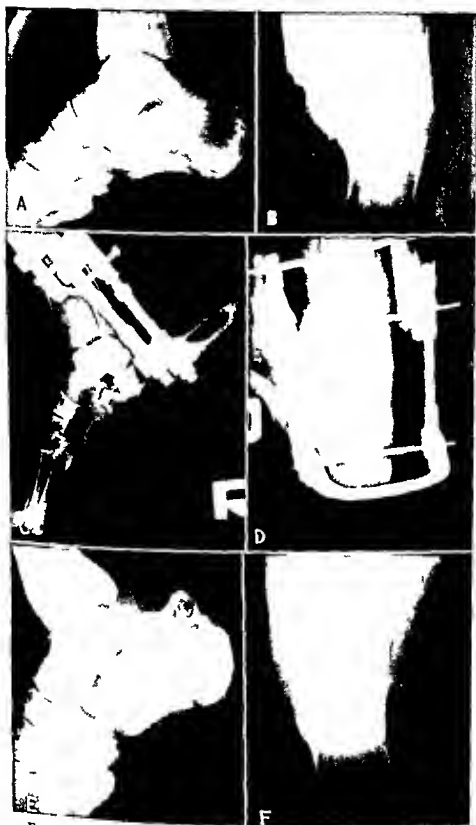


Fig 76 (Case II S B) —A Preoperative lateral x ray view B Preoperative x ray plantar-dorsal view C Postoperative x ray view D Postoperative x ray plantar dorsal view E F Final x rays after removal of splint

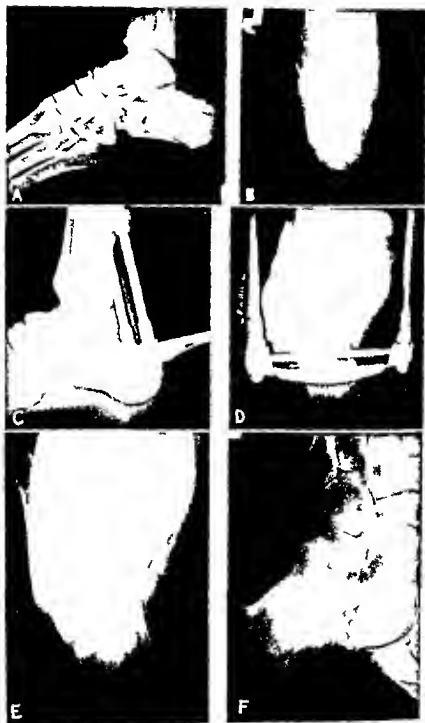


FIG 77 (Case III M M) —A Preoperative x ray lateral view B Preoperative x ray plantar dorsal view C Postoperative x ray lateral view D Postoperative x ray plantar dorsal view E F Final x ray after removal of splint

CASE III (Fig 77) —M M aged thirty nine years fell from a one story roof and landed on his right heel sustaining a moderate comminuted and compressed fracture of the right os calcis. He was admitted on June 8 1942 a few hours after the injury. Reduction was done on June 16 and the splint removed July 28. Weight bearing began August 20. The patient was discharged from the hospital on August 24 on crutches. Free subastragaloid motion was present without pain. He returned to work as a Navy Yard employee on December 7 1942.

CASE IV—V S aged fifty two years fell 8 feet and landed on his left heel a few hours before admission on August 8 1942. The x ray showed a moderate comminuted and compressed fracture of the left os calcis. Reduction was done on August 18 and the splint removed on September 29. Weight bearing began October 19. The patient was discharged from the hospital on crutches on October 20 1942. Excellent subastragaloid joint motion was present with minimal subjective complaints. He will be able to return to work about January 10 1943.

SUMMARY AND CONCLUSIONS

A new method of approach to the problem of the treatment of comminuted and compressed fractures of the os calcis is presented. The following advantages are noted:

- 1 The *reduction fixation splint* is complete in itself and requires no additional equipment except an os calcis clamp.
- 2 It permits not only *reduction* of the fracture, but becomes the *splint* upon completion of the reduction.
- 3 No reduction frames or plaster of paris are required.
- 4 The type of pin placements and rigidity of the splint allows for accurate constant controlled traction in the *desired tangent* for reduction of the disparity of the tuber joint angle as well as the shortening.
- 5 The constantly controlled traction permits overextension to produce sufficient space into which the laterally displaced fragments may be easily replaced *often by hand*, or compressed by means of the os calcis clamp.
- 6 The turnbuckles permit controlled tangential traction in either *valgus* or *varus*, thus allowing maintenance of the normal varus position of the os calcis during the period of

fixation, as well as permitting exaggeration of either valgus or varus during the reduction

7 *The integrity of the subastragaloid joint space is constantly maintained throughout the period of healing thereby assuring better joint motion and consequently less pain or development of post traumatic joint changes*

8 *The rigid fixation promotes earlier union*

9 *Secondary adjustments may be made at any time without sacrificing the reduction already obtained*

10 *Active motion of the knee and toes and ambulatory activity on crutches promotes better circulation and permits transportation of the patient without assistance*

11 *The constant rigid fixation of the fracture without the use of plaster or pressure pads insures a smooth uneventful convalescence without pain, discomfort, or complications due to the use of plaster*

12 *The actual application of the splint is remarkably simple and whereas a thorough knowledge of the general principles of the treatment of the difficult os calcis fracture is essential in any method of treatment the simplicity of the application of this method of approach makes it more generally applicable to the average traumatic surgeon without unnecessary danger to the patient*

13 *This new method of approach to the problems offered by fractures of the os calcis is based on sound anatomical and physiological principles and accurately satisfies the fundamental requirements of fracture treatment*

14 *The basic requirements of accurate reduction, rigid uninterrupted immobilization and very functional restoration are better and more accurately applied in this method than in any other including the Bohler method*

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JOHN J. MOORHEAD MD DSc FACS

AFTER sixteen months of war for our military forces it now appears that certain surgical practices have been sufficiently employed for comparative appraisal. For our purposes it can be stated that the prevailing casualties are (1) wounds (2) fractures and (3) burns.

Until January 1, 1943, the only large surgical experience of our own forces was the Pearl Harbor attack, and hence reference to some of the lessons learned there will be mentioned. There is, however, an abundant literature, especially from British sources, not only as to actual combat but also as to civilian air raid casualties. Some information has been transmitted from Russian and French sources, but comparatively little is known as to German surgical practices and even less about the Japanese.

BASIC FEATURES OF TREATMENT

The basic features of treatment in war injuries may be said to revolve around the following points:

1. *The time element* It is conceded that the time lag between the onset of injury and definitive treatment is *the* most important element. For many years this factor has been stressed by me in every form of traumatic surgery, and to emphasize this feature I have called this the "Golden Period" and designated it as six hours. There has been some advice to extend this period to eight hours or more on the theory that debridement plus applications of a sulfa drug makes the

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delay safe. This recommendation is probably advisable for veteran war surgeons but the fact remains that this conflict will be won surgically by those new to war conditions just as it will be won in a military sense by our combatants fighting for the first time.

2 *The shock element* The applicable rule is not to undertake any extensive operative procedures unless the blood pressure is over 90. When shock and hemorrhage coexist it may not be possible to fulfill this important requisite. For shock the outstanding remedy is blood—usually plasma and serum are the available products because whole blood is often unobtainable.

3 *Debridement* is the recognized treatment for any extensive wound and associated with this is the recommendation that sutures should not be used.

4 *Dressings* should be ample on the principle that immobilization is an important element too often neglected. Redressings are deferred beyond the third day unless there are good reasons to the contrary. Great care is then necessary to prevent reinfection since there is accumulating evidence that invasion by the hemolytic streptococcus and other bacteria is more often a secondary than a primary complication. Dust and the nose and throat infection of a surgeon or others are the accused factors and for that reason the use of masks is advisable.

5 *After care* is often featured by the use of transfusion and when obtainable this stimulating factor should not be too long delayed.

Following are some of the factors relating to the three prevalent casualties.

1. WOUNDS

1 *The cleansing element* universally advised in wounds is soap and water used often enough to provide as clean a field as possible after the manner of washing the hands of the operator. Antiseptics are often more harmful than helpful.

2 *The debridement element* aims to remove all the damaged tissue by a process of excision. This feature is complete when three criteria obtain: (a) the tissues look normal; (b) the tissues bleed; and (c) the tissues contract (if muscle).

This excision is not to be performed in terms of inches or centimeters but on the contrary the extent of the removal is determined only by the criteria named. The excision should not be sacrificial and if severed nerves or tendons are encountered they are sutured with silk or tagged for future repair.

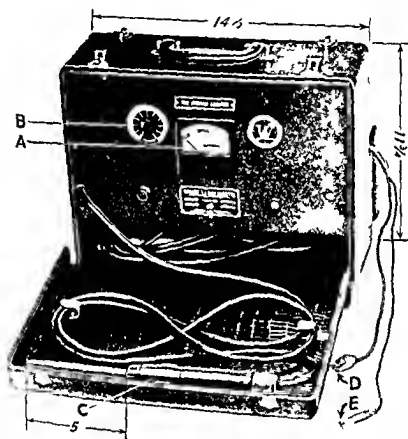


Fig. 78—The Locator foreign body finder. In size and shape it resembles a portable radio. It responds for iron, steel, copper, brass, aluminum, lead, and other metals. A, The registering dial; B, The tuning knob; C, The probe or finder; D, The plug-in wire; E, The ground wire.

Foreign bodies are removed if accessible but often they are deliberately undisturbed if the search would be prolonged or mutilating. The difficulty in finding missiles is well known and despite their size and good localization by x-ray it is often impossible to find them. The use of the *Locator* (see Fig. 78) proved very helpful among the Pearl Harbor casualties.

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TRENDS IN WAR SURGERY

JOHN J. MOORHEAD M.D. D.Sc. F.A.C.S.

AFTER sixteen months of war for our military forces it now appears that certain surgical practices have been sufficiently employed for comparative appraisal. For our purposes it can be stated that the prevailing casualties are (1) wounds (2) fractures and (3) burns.

Until January 1, 1943 the only large surgical experience of our own forces was the Pearl Harbor attack and hence reference to some of the lessons learned there will be mentioned. There is however an abundant literature especially from British sources not only as to actual combat but also as to civilian air raid casualties. Some information has been transmitted from Russian and French sources but comparatively little is known as to German surgical practices and even less about the Japanese.

BASIC FEATURES OF TREATMENT

The basic features of treatment in war injuries may be said to revolve around the following points:

1. *The time element* It is conceded that the time lag between the onset of injury and definitive treatment is the most important element. For many years this factor has been stressed by me in every form of traumatic surgery and to emphasize this feature I have called this the "Golden Period" and designated it as six hours. There has been some advice to extend this period to eight hours or more on the theory that debridement plus applications of a sulfa drug makes the

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and this electromagnetic induction apparatus is now available commercially. It determines the surface location as well as the subsurface depth and if necessary the probe or finder can be placed in the open wound as an additional aid. This apparatus was devised for me by Samuel Berman of the electrical engineering department of the New York City Transit System. The first trial of the device was at the Reconstruction Unit of the New York Post Graduate Hospital just before I left for Honolulu. This initial success was in the case of a police officer who had been injured in the bombing incident at the New York World's Fair. I took the original apparatus with me to demonstrate to the members of the Honolulu Medical Society where I was their guest lecturer on the subject of Traumatic Surgery. The first miss usage of the device was after the Pearl Harbor attack in an Army Hospital while I was on active duty there as Colonel Consultant. The original apparatus was left at this hospital and improved models were later manufactured here and have been used by me in eleven civilian cases with uniform success.

3 *The sulfa drug element* After debridement a sulfa drug is liberally applied in every section of the exposed surface. Sulfanilamide is preferred because it does not calcify and hence will not retain secretions. Some of the other sulfa products however are now available in a granular form that renders them less occlusive than heretofore.

4 *The no suturing element* The debrided wound is left wide open if it is extensive or comminuted otherwise sutures are placed but left untied until after the third day. Suturing in any war wound is a needle's hazard. Indeed coaptation after the third day effects almost the same grade of union as if immediate or primary suture had been performed.

5 *The after care element* Firm massive gauze dressings with splintage of adjacent joints is advisable. No redressings are done until after the third day unless indicated (pain secretion temperature) and these are done with the precaution to avoid secondary infection. A sulfa drug is given for the first three days after the operation or the trauma usually sulfathiazole in a dosage of 15 grains every four hours. Constitutional effects from the drug are usually avoided if the urinary output is kept at 1000 cc daily.

These five elements are now practically standard procedures and war surgeons with almost complete unanimity subscribe to them for wounds of the soft parts or elsewhere

II FRACTURES

Fractures are usually of the grossly compounded variety and for this reason the preceding elements of wound treatment are even more applicable. In some cases primary suture may appear tempting when the tissue and bony injury is apparently minor. Wisdom dictates that this should not be done however for after all a fracture is a wound of bone thus in the treatment of a wound of the soft parts *and* of the bone there is a double reason for refraining from closure.

There is considerable controversy regarding immediate plaster encasement after debridement and many recommend this method as routine especially if the victim has to be transported promptly. Obviously the procedure should not be used when measurably complete reduction is impossible and thus in many cases of femoral and leg fracture it is inapplicable. In front line formations during a rush period the use of plaster is often impracticable and incidentally further messes up the operating room. Our practice during the Pearl Harbor attack was to use immediate encirclement only when the bony and soft part comminution was minimal. Reduction was otherwise maintained in a Thomas or other type of splint and skeletal traction was also used. Plating was not employed. After the third day plaster was applied if all was well. In other words the delayed suture method applied to soft part wounds was likewise applied to wounds involving bone (fractures). In passing let it be stated that in every case of gas gangrene we encountered the wound of compounding had been sutured and no complication of this sort occurred in the nonsutured group.

III BURNS

For many years the writer has classified a burn as a wound originating from thermal chemical electrical or radiant energy sources. This places burns in the treatment class of soft part wounds and osseous wounds (fractures). Basic treatment thus follows the pattern mentioned for other

wounds again with emphasis on (1) the time element (2) the shock element (3) the cleansing element (4) the debridement element (5) the dressing and after care element

Plasma is definitely the best antishock medium in this group and relief from pain is a coincident factor. Here let it be stated that morphine is the sovereign pain relief remedy in all the traumas and it should be given in *every* case with probably the sole exception of any casualty when diagnosis is uncertain notably in cranial and thoracic blast casualties. The dosage should be $\frac{1}{2}$ grain or more taking the precaution to tag the victim to indicate what has been done.

There is much controversy as to the best treatment of burns and even in Great Britain there is no unanimity of opinion despite the accumulated heroic experience in military and civilian sectors. There are several schools of thought and to reconcile these divergent opinions is difficult. The essential aims are (1) to relieve pain (2) to combat primary and secondary shock (3) to promote healing and (4) prevent infection and deformity. The relief of pain and the shock elements are practically standardized and have been mentioned above. Healing is promoted by any medium that stimulates the secreting surface and at the same time prevents fluid loss and avoids secondary infection. The use of occlusives of the rigid type of tannic acid with or without dyes is less in vogue than hitherto and is not to be recommended on mobile parts. An additional disadvantage is the necessity for repeated dressings, sprays or otherwise because the personnel is not always available. Likewise infection is a hazard despite adequate chemical tanning. The present acceptable form of occlusive is designed to cover the surface with a transparent elastic antiseptic film that adequately protects without massive dressings. Most of these products have a sulfa base usually sulfanilamide or sulfathiazole. Another type of occlusive has an oily base such as mineral oil, cod liver oil or vaseline in combination with sulfa drugs. Immobilization of the burned surface is just as important as in any other type of wound with the precaution to enforce mobility in affected joints and in burns of the face or hands and feet.

My personal preference is for an application of sulfanilamide and sulfathiazole each 15 per cent in a mineral oil

cod liver oil or vaseline base. This is applied after careful debridement of loose tissue blebs and otherwise devitalized tissue. Re dressings are done with great care so that reinfection is prevented. It should be borne in mind that infection is often transmitted by the surgeon, nurses or others who have a nasopharyngeal infection and thus are carriers.

In a recent experience the application of the *discarded red cells* in plasma preparation was found exceedingly useful. This was a patient of Dr. Harry V. Spaulding at the Reconstruction Hospital who had extensive suppurating burns of both lower extremities. Many types of treatment had been tried in vain and at my suggestion a dressing of red cells discarded from many donors was applied. The outcome was extremely satisfactory; the purulent exudate disappeared promptly and later a massive skin grafting by Dr. Spaulding was successful on both extremities. One outstanding effect was the rapid change in the patient's general state. This red cell covering has the consistency of thick paint and it is applied with a brush or cotton applicators directly to the raw surface and promptly produces an elastic film protective. Later in conjunction with Dr. Lester J. Unger, hematologist of the Post Graduate Hospital, we propose to add a sulfa drug for further trials. The first use of this preparation was in a delirious patient of mine who had torn apart my knee joint arthrotomy incision. In this case the open joint was filled with this semiliquid preparation and to my great surprise aseptic healing proceeded rapidly and a mobile joint resulted. Several cases of infected wounds have responded satisfactorily and Dr. Unger and I are of the opinion that this discard will prove to have a useful field.*

ANESTHESIA

Anesthesia is very important in war wounds and accumulating experience commends the intravenous route in preliminary treatment and for long procedures as well. In the Pearl Harbor attack we found it helpful to use this method in connection with infusion or transfusion; the anesthetic being introduced through a hypodermic stab wound in the tubing close to the opening in the vein. One desirable feature of

intravenous anesthesia is the smooth induction and recovery both of which prevent the tossing about so disturbing in bleeding wounds and in fractures. An added feature is the ease of administration during a rush period when personnel are often at a premium. Ether combined if possible with oxygen is doubtless the safest medium. Spinal anesthesia has a definite place but often postspinal headache and bladder involvement are undesirable complications. Local anesthesia has very limited application but nerve block is sometimes useful in carefully selected cases.

It is pertinent to add that the principles as outlined for the treatment of war wounds are equally applicable to civilian casualties in wartime and to a very large extent to many of the traumas of peacetime civil life.

TRAUMATIC SHOCK ITS PREVENTION AND TREATMENT*

CHARLES G. CHILD III M.D.

ALTHOUGH James Latta¹ is generally credited with the first (1795) comprehensive description of shock following injuries LeDran employed the word shock in association with gunshot wounds a number of years earlier. In 1743 he wrote the Bullet "thrown by the Gun powder acquires such a rapid Force that the whole animal Machine participates more or less in the Shock and Agitation." Thus almost two hundred years ago the term shock was introduced to designate the startling clinical picture which may appear in the victims of severe injury. Since it is not germane to this chapter to review the hundreds of clinical observations and experiments that have marked the development of the present concept of shock reference is made to anyone of the excellent and recently published surveys of the subject.^{2, 4, 6} It is the purpose here to consider only the prevention and treatment of shock as it is encountered following various types of trauma.

PRESENT CONCEPT OF SHOCK

Under the heading of shock has been amassed an agglomeration of general systemic reactions which when fully developed present a readily recognized clinical picture following an injury. The victim is pale and cyanotic, there is excessive perspiration, his extremities are cold and clammy, his pulse rapid and thready, he is apathetic and his blood pressure may be low. For many years this clinical picture represented shock and little effort was made to differentiate the conditions under which it appeared. Today, largely as a result of clinical and experimental investigations stimulated by the experiences of surgeons and physiologists during World War I, this attitude is no longer tenable.

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It is now recognized that shock varies significantly according to the conditions under which it develops. Thus the type of shock that follows hemorrhage differs from that encountered after severe burns, shock appearing after a severe crushing injury differs from that due to insult to the central nervous system. So significant is this change in approach that it would undoubtedly be wise to drop the word shock entirely. Common usage, however, makes this impossible and the word will probably be retained. Much can be accomplished, however, if a descriptive phrase be added, such as shock due to hemorrhage, shock due to burns, postoperative shock, and so on. The reason, of course, for clearly differentiating the various forms of shock is that the treatment of choice varies in each type.

THE PREVENTION OF SHOCK

Although a great part of the present knowledge of shock as a problem has been derived from experiences in traumatic surgery, elective surgery, and the experimental laboratory, have made an outstanding contribution by demonstrating that shock can be prevented. The period of effective prophylaxis is inherent in adequate preparation for operation. Correction of an anemia, an hypoproteinemia, a disturbed fluid balance, a severe nutritional or vitamin deficiency, and insofar as possible of cardiac and renal malfunctions, has resulted in the disappearance of one type of shock, namely, postoperative shock, as seen in elective surgical practice. Even as anesthesia and aseptic technic marked new eras in surgery, so has the virtual abolition of postoperative shock from the modern operating room and ward marked another.

In traumatic surgical practice, however, the principles learned in elective surgery are difficult to apply. In civilian life the automobile cannot be relied upon to injure only those in excellent health; during an air raid men, women, and children in all walks of life become the victims of severe injury. In the treatment of injuries sustained during active warfare the wounded are frequently the victims of exposure, exhaustion, malnutrition, and dehydration, all of which states are recognized as factors predisposing to the development of shock. This does not mean that it is impossible to apply the

principles of prevention in treating the injured. If every victim of an injury, no matter how superficially trivial, be considered potentially in shock and be kept under close observation for a period of a few hours before being subjected to any operative procedure, the appearance of shock can be effectively prevented. Unless there is active hemorrhage, few wounds require such immediate operation that a much needed transfusion of blood or plasma cannot first be administered or a severely deranged fluid balance corrected. Even in the direst emergency the institution of a continuous transfusion will often assure the successful outcome of an operation which otherwise might well have resulted fatally.

An impressive witness to the importance of the concept that shock can be prevented is the so called "shock ward." In recent years such specially equipped departments have been developed wherever an institution has found itself faced with the possibility of having to treat large numbers of injured persons. Here are sent immediately not only those who are actually in shock, but also those who present evidence that this complication might develop. Therefore, even in traumatic surgery attempts to prevent the development of shock have been sufficiently successful to warrant their institution in every case.

THE EARLY DIAGNOSIS OF SHOCK

During periods of stress and in dealing with large numbers of injured, the accomplishment of the ideal of prevention may not always be possible. Because of this and also because of the fact that when the classical signs and symptoms are present shock is in a very late and often irreversible stage, it has become imperative to attempt to recognize this complication in its incipency. Blalock and Price¹ have recently outlined what they consider the earliest signs of impending shock.

1. *Downward trend in systolic arterial blood pressure.* It is to be emphasized that this downward course is far more important than any arbitrary value. In order to detect this trend, blood pressure determinations must be made every ten to twenty minutes. A progressive fall, therefore, can be considered one of the earliest and most useful signs of impending shock, except in that type which follows burns. Here hemo-

concentration is the first sign and this may precede blood pressure changes by many hours

2 *Reduced minute volume flow of blood through the skin* Although this can be measured accurately in experimental shock there are too many technical difficulties involved in its determination in human subjects Blalock and Price⁷ describe as follows a clinical test which they consider useful

press the finger against the sternum lift it off quickly and note the time required for the blanched area to turn pink again Normally this is a rapid process requiring perhaps less than a second in early shock the reaction is noticeably slower

3 *Reduction of oxygen content of venous blood* Accurate estimation of this value is too time consuming for clinical application but these authors⁷ feel also that there is an important point to be made in this regard If during an operation the patient is breathing freely and yet the venous blood in the incision appears unusually dark it should be regarded as a danger signal of impending or developing shock

Early shock is associated with many other changes such as reduction of plasma volume decreased alkali reserve and decreased cardiac output but measurement of these changes though possible in the laboratory is too impracticable to be of any real value in estimating whether or not early shock is present It should be emphasized therefore that while the above criteria of early shock may be helpful there is as yet no single index which can be relied upon to foretell whether or not this complication will appear

EMPIRICAL TREATMENT OF SHOCK

In the prevention and treatment of shock in both its incipient and fully developed forms there are several general principles which have withstood the test of clinical application over many years

1 *Rest*—Perhaps no single measure goes back as far in the therapeutic annals of shock as absolute rest and quiet This applies not only to the individual as a whole but also to the specific part which is injured During World War I the striking reduction of the mortality in fractures of the femur by merely splinting the involved extremity bears witness to the

importance of complete rest. In civilian practice the increasing emphasis placed upon the maxim of splint them where they lie is significant.

2 *Relief of Pain*—In order to accomplish the ideal of complete rest nothing is more important than the relief of pain. In this respect morphine persists as the drug of choice. In its use one note of warning is necessary, namely, that overdosage sufficient to depress an already inadequate respiratory exchange is to be avoided. Probably from 0.01 to 0.02 gm. as an initial dose should be considered adequate. This may be repeated as necessary in similar amounts. Further morphine is to be avoided in severe head injuries in which intracranial injury may have rendered the respiratory center partially incompetent.

3 *Heat*—Almost as old and as important as rest in the treatment of shock is the application of heat. Although this found its origin in clinical experience it has been amply verified in the laboratory, for exposure to low temperatures greatly facilitates the production of experimental shock. The application of too much heat is of course to be avoided because by the production of a peripheral vasodilation the available circulating blood volume may be further depleted thereby increasing the severity of the shock.

4 *Position*—The use of the so called shock position has long been a popular method of combating shock. At first this was an outgrowth of the idea that by elevating the extremities and lowering the head the central circulation could be increased. Although accepted for many years as a most useful procedure its benefits have recently been challenged. This position of course should not be employed in patients with severe intracranial or intrathoracic injury.

5 *Oxygen*—Largely based on laboratory experiences the administration of high concentrations of oxygen preferably by means of the B. D. face mask theoretically should be of benefit in the treatment of shock. Though possible in civilian practice this has proved impossible in war because of the difficulties and hazards involved in the storage and transportation of oxygen cylinders.

6 *Vasoconstrictor Drugs*—There is now available a host of these drugs. Though it is difficult to gather from the litera-

ture any unanimity of opinion as to their usefulness it now seems probable that those recommended for the treatment of shock instead of being beneficial may actually be harmful. At the present writing it is difficult to recommend any one of the many preparations on the market.

7 *Adrenal Cortical Extract*—The evidence at hand at the present time as to the effectiveness of adrenal cortical extract is controversial. Although some reports are encouraging it cannot be said that its usefulness has been established. Contrary to vasoconstrictor drugs however no harmful results have been noted and so if one of the potent extracts is available it should be administered. Furthermore its use seems to be more effective in preventing shock than in its treatment.

THE TREATMENT OF SHOCK FOLLOWING VARIOUS TYPES OF INJURY

Although it was stressed in several of the preceding paragraphs that many types of shock could be entirely prevented the commonest situation with which the surgeon is all too frequently confronted is that of a victim of injury manifesting the signs and symptoms of well developed shock. As it is now uniformly admitted that the *sine qua non* of the treatment of shock is the administration of blood or of plasma or serum the remainder of this section will be devoted to the consideration of this important problem. Furthermore since shock differs significantly with the nature of the injury which it follows each general type encountered in traumatic surgery will be considered separately and in the order of its importance. It should not be inferred however from the following subdivisions that it will be possible always to determine exactly which type of shock exists. In caring for the injured it must be recognized that more than one of these factors may exist. For instance in a severe compound fracture of an extremity soft parts may be badly torn muscles crushed and hemorrhage may have been profuse from torn vessels. In such a patient therefore clinical estimation of the significance of each factor will ever play an important role. To attempt to overstandardize or oversimplify the treatment of shock would of course be a gross error.

Treatment of Shock Following Hemorrhage

The type of shock with which the surgeon has to deal most frequently is that following severe hemorrhage. Although the literature is replete with oftentimes confusing analyses of the physiological derangements consequent upon the loss of any considerable quantity of whole blood it is now generally accepted that shock as seen under this circumstance may be termed peripheral circulatory failure. The course of events may most easily be conceived of as (1) severe loss of blood leading to a depleted blood volume and (2) imperfect cardiac filling which in turn is followed by (3) decreased cardiac output (4) low blood pressure and finally (5) cardiac failure and death. If the hemorrhage is enormous the outcome is immediately fatal and shock never develops. If however the hemorrhage is less in amount is prolonged or is repeated the picture of shock then appears. If allowed to go uncorrected the changes described as the late or irreversible stage of shock develop i.e. diminished blood flow tissue anoxia low blood pressure hemoconcentration and finally death. Of primary significance therefore in the treatment of shock following hemorrhage is the *early rapid and adequate replacement of the blood lost*.

The evidence indicating that the early replacement of the blood lost is of primary importance comes from the experimental laboratory. Here it has been shown that if animals are subjected to the withdrawal of blood the picture of shock will develop. If this blood is replaced by transfusion as soon as it is withdrawn shock can be prevented. If however a period of time is allowed to elapse before its return death due to shock will take place and the frequency of its occurrence will depend directly upon the length of this time interval. Since as indicated previously there are no reliable signs in man to indicate just how severe shock may be it is imperative to start the replacement of the blood lost at the earliest possible moment. A delay perhaps only of thirty minutes may allow shock to progress to its stage of irreversibility in which replacement therapy is of no avail. The significance of this factor in the prevention and treatment of this complication is reflected in the efforts that are being made

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Weiner Rowlette and Elman⁸ reported the first clinical cases in which plasma was used in the treatment of this type of shock. Harkins^{9, 10} has written extensively on this problem.

In 90 percent of patients with severe burns (those deep enough to cause blistering) evidence of shock due to plasma loss is present by the time the victim comes under surgical care. The reason for this is that the greatest proportion of plasma loss takes place within the first two hours or so following injury. Aside therefore from the general supportive measures which have been indicated previously, the most significant factor in treatment of the shock following burns is the prompt administration of adequate amounts of plasma. As a result of the difficulties that have been encountered in determining what constitutes an adequate amount, several clinically useful formulas have been developed. Probably the simplest of these are the two methods of Harkins.¹⁰

1 *Fifty cubic centimeters of plasma for every per cent of body surface affected.* In these patients the percentage of body surface burned can be determined practically and rapidly from Berkow's table.

BERKOW'S TABLE FOR DETERMINING PERCENTAGE OF BODY SURFACE BURNED

Region	Per Cent of Body Surface Involved
Head	6
Upper extremities	
Both arms and forearms	13.5
Both hands	4.5
Total	18
Trunk	
Anterior surface	20
Posterior surface	18
Total	38
Lower extremities	
Both thighs	19
Both legs	13
Both feet	6
Total	38

This method is particularly useful where no laboratory methods are available.

2 *One hundred cubic centimeters of plasma for every point the hematocrit exceeds the normal of 45.* This method

the various types of shock must be considered significantly different in their treatment

4 Hemorrhagic shock requires the early rapid and adequate replacement of the blood lost

5 Shock following burns demands replacement of the plasma lost

6 Empirical methods of treatment are useful but fluid replacement therapy is essential

7 Crystalloid solutions should not be used in the treatment of shock except in those patients presenting a severely deranged fluid and electrolyte balance

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INDICATIONS FOR THE USE OF BLOOD AND BLOOD SUBSTITUTES IN SURGERY

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THE purpose of this clinic is to emphasize the importance of following a rational plan in using blood and blood substitutes in surgery. It has frequently been the custom in the past to order a transfusion or an infusion leaving the kind and amount of blood or blood substitute to the discretion of a subordinate. In the vast majority of cases the amount of blood transfused has been 500 cc. perhaps because it has become the custom to draw that amount from the donor. Similarly in the use of glucose and saline the amount given the patient has usually been 1000 cc. since that is the amount made up in flasks. It would be just as rational to give every patient with diabetes mellitus 10 units of insulin.

The wide prevalence of blood banks has resulted in an increase in the number of blood transfusions. Whole blood, plasma and serum have been used indiscriminately and in insufficient amounts. It is essential that the requirements and characteristics of the patient be carefully considered and the advantages and limitations of the various kinds of fluids borne in mind to obtain the most beneficial results from intravenous therapy. Then too one must consider the particular function of the blood that requires reinforcement.¹

CONDITIONS REQUIRING INTRAVENOUS ADMINIS- TRATION OF FLUIDS

Shock

To await the classical picture of shock such as pallor, cold moist skin, rapid thready pulse, shallow respiration, low blood pressure, anxiety and subnormal temperature is to put oneself in the position of treating late or uncompensated shock.

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In the majority of cases the factor of shock is present or can be suspected from the type and extent of the trauma or surgical procedure although it is not severe enough to produce the classical clinical picture. In many such cases changes can be detected in the blood volume and hematocrit reading that are indicative of impending shock. The significance of hemoconcentration as an early sign of shock has been emphasized by Moon.³ Appropriate treatment at this stage will prevent the appearance of the classical picture of shock. White⁴ and his co-workers advise treatment in the presence of two or more of the symptoms of shock and all writers agree that the best results are obtained when the therapeutic measures are instituted before the clinical symptoms have developed.

It is generally accepted today that an essential feature of shock regardless of cause is a disparity between the amount of circulating blood and the size of the vascular system. This may occur either by loss of fluid from the circulation or by an uncompensated increase in the size of the vascular bed.⁵ The mechanism of shock following severe injuries may be due to neurogenic or hematogenic factors. Pain, fright and concussion produce the neurogenic factor to which hemorrhage and loss of plasma into the injured area may be added. Of the various factors that operate in shock some are a primary cause of the reduced blood volume others secondary to it. The pathologic changes in the viscera resulting from shock are not specific but once established are irreversible. These changes in the lungs, liver, kidneys and gastro-intestinal tract result from dilated, congested capillaries, hemorrhage and edema. The anoxia produced in the tissues is the result of these injuries is responsible for the irreversibility of the shock syndrome.⁶

In different clinical conditions the proportionate importance of the various causative factors of shock varies and in some more than one cause may be active.⁷ In hemorrhage the loss of blood is the important factor; in burns it is chiefly plasma and in traumatic shock there is a loss of both whole blood and plasma. It is significant whether the fluid loss is sudden or gradual since a patient can sustain a greater loss of fluid over a period of time than he can if the loss is sudden. The primary result of fluid loss is an oligemia with associated

vasoconstriction decreased cardiac output and decreased blood flow. This latter produces an anoxia and a resultant capillary wall and cell injury. Hemoconcentration results from the generalized capillary wall injury.

Following a severe injury so called *primary shock* frequently occurs. This is a vascular collapse in which the tone of the peripheral vessels is diminished reflexly as a result of nervous and psychic stimuli.⁸⁻⁹ The vascular bed is dilated to such an extent that the volume of blood becomes insufficient to maintain an adequate output to the periphery. As it is difficult to distinguish this form of collapse from true secondary shock, it is urgent that such patients be treated immediately for collapse. This treatment includes the administration of morphine (intravenously if necessary) getting the patient warm and placing him in shock position with the feet elevated.

In *secondary shock*, due generally to the loss of blood or of one of its components it is important immediately to replace the fluid loss and to prevent further loss of fluid. Replacement of fluid is accomplished by adequate *blood* or *plasma* transfusion. Due to the irreversibility of the tissue changes when shock has been present for some time the prevention of further fluid loss is more difficult. The use of oxygen and adrenal cortical hormone has recently been added to our armamentarium for the treatment of this stage of shock.¹⁰ Inhalation of oxygen is said to prevent further anoxia and the adrenal cortical hormone prevents the increased permeability of the capillary wall and cell membrane. However these measures are not always effective and it is safest to treat shock before the tissue changes and clinical symptoms have developed.

Hemorrhage

Secondary shock following hemorrhage presents a different therapeutic problem from primary shock. If more than one third of the blood in the body is lost death will result unless the blood can be replaced rapidly. Should the blood loss be gradual the patient can be saved even when two thirds of the total volume have been lost.¹¹ A patient who has lost a considerable volume of blood from hemorrhage may not

appear different from a normal person however he cannot tolerate a further loss of a small amount of blood that would not affect a normal person

In hemorrhage therefore the ideal therapy is replacement with *whole blood* since both red cells and plasma have been lost. When it is desired to give blood rapidly whole blood transfused by a direct method is best. Since this would necessitate having a compatible donor on hand this method is not always feasible. Stored blood administered through a large gauge needle is almost as efficacious provided the stored blood is not more than several days old. As a general rule the fresher the blood the less will be needed.

If no whole blood is available *plasma* may be given to tide the patient over the acute period until whole blood can be obtained. After a hemorrhage the concentration of hemoglobin is little altered at first but then gradually falls as the blood volume is brought back to normal by the production of plasma from the patient's own reserve. When the hemoglobin falls below a certain level this process of hemodilution does not continue. Therefore when a low hemoglobin value is found at the start it is unwise to administer plasma alone. The experience of the British has borne this out. The importance of this is emphasized by the fact that hemorrhage treated before shock ensues is cured in 85 per cent of the cases whereas only 40 per cent are helped after shock has developed.

ESTIMATION OF THE AMOUNT OF FLUID REQUIRED

The best therapeutic result would be obtained if the fluid lost by the body in hemorrhage from wounds or from the gastro intestinal tract were replaced by an equal amount of the same fluid. The tendency has been to replace lost blood by an inadequate amount. Since after acute blood loss hemoconcentration occurs for twenty four to thirty six hours the determination of hemoglobin values as a guide to blood loss is inaccurate during this period. The safer procedure would be to estimate the blood loss from the clinical picture and give 250 cc. more than the estimated value checking the hemoglobin forty eight hours later and transfusing more blood as required. One may expect a rise of approximately 10 per cent

in the hemoglobin value for each 500 cc of fresh whole blood transfused

Several methods of estimating the *loss of plasma* have been advocated. The First Aid formula is to give 50 cc of plasma for every per cent of the body surface affected by burns. Berkow¹³ suggests giving 100 cc of plasma for every point the hematocrit is above 45. A formula for calculating the blood volume of a wounded patient by comparing the hematocrit reading before and after a plasma transfusion has been devised by Bushby¹⁴ and his co workers.

For controlling the fluid requirement of *surgical patients* several factors must be considered. The amount of fluid lost from the gastro intestinal tract by vomiting (gastric biliary and pancreatic juices) should be estimated and replaced by an equal amount of 5 per cent glucose in saline. Fluid lost by insensible heat loss which may amount to 1 to 2 liters must be replaced. Maddock and Collier¹ found that about 1000 cc of fluid was lost by the average surgical patient at the time of operation approximately 700 cc was lost by vaporization usually due to the old fashioned custom of sweating the patient on the operating table and to the use of warm blankets and hot water bottles. The other 300 cc was lost in blood vomitus and urine.

In certain *severe cases* it may become necessary to do repeated simultaneous hematocrit plasma protein carbon dioxide combining power and chloride determinations¹⁵ to control the water and electrolyte balance. From these values together with the clinical picture and the volume and specific gravity of the urine the degree of hydration can be estimated. Determination of the chlorides and carbon dioxide combining power indicates the total base which is an index of the amount of water held in the tissues. In a patient who is not vomiting and who can retain fluid by mouth the usual fluid intake including diet is 3000 cc. If the patient voids about 1500 cc daily the fluid intake is adequate. If parenteral fluids are given calculate 2000 cc for water of vaporization 1500 cc for urine and an equal replacement of the fluid lost in vomitus diarrhea hemorrhage and so forth. In severely dehydrated patients add about 6 per cent of the body weight or about 3600 cc.¹ Collier¹⁶ advises giving 0.5 gm of sodium chloride

per kilogram of body weight for each 100 mg the plasma chloride must be raised to reach the normal of 560 mg per 100 cc

INDICATIONS FOR THE USE OF THE VARIOUS KINDS OF BLOOD AND BLOOD SUBSTITUTES

In the choice of blood or a blood substitute one should have clearly in mind the particular function of the blood that requires reinforcement. These functions are interrelated and include oxygen transport by the erythrocytes, maintenance of osmotic pressure and nutrition by the plasma proteins, coagulation by the prothrombin-fibrinogen mechanism, phagocytosis by the leucocytes, and participation in the body response to infection by the complement and circulating antibodies.¹ The general condition and age of the patient must also be considered for the rapid replacement of a large quantity of blood in an old person even if trauma has resulted in moderately severe hemorrhage may overburden the heart and result in cardiac dilatation. Similarly, in patients suffering from asthma, lobar pneumonia or other pulmonary disease, rapid infusion of blood should be avoided. Severe reactions have resulted from the transfusion of blood into allergic recipients so that even though the need for blood following hemorrhage or trauma be great, inquiry into the ingestion by the donor immediately preceding phlebotomy of food or drugs to which the recipient is known to be sensitive should be made. One must also remember that in traumatic injuries and following surgical operations the patient will not be restored at once to full health. Problems of nutrition, dehydration and infection may arise and the patient's ability to replace water, protein and the formed elements of the blood will be impaired for some time.

Whole Blood

In *severe acute hemorrhage* unmodified whole blood is the best replacement. It has the advantages that it can be administered rapidly, no foreign substance has been added and the platelets are intact. Its use is limited, however, in that a proper donor is not always available, it must be injected rapidly or clotting will occur, and it must be given by direct transfusion. Because of these technical difficulties, it

is seldom used at present except in such conditions as hemorrhagic diseases and jaundice

Fresh citrated blood a few hours old is as effective as unmodified blood in hemorrhage. It fortifies the blood in all its functions and all substitutes are inferior to it except in cases of severe burns in which there is a marked hemoconcentration and plasma has been proved to be more useful.

Citrated blood stored for a few days is almost equivalent to fresh blood. Stored blood may be used where the need is for erythrocytes in *acute hemorrhage* and in *shock*. It is frequently used as a preoperative or postoperative measure. However, blood stored longer than one week is relatively inefficacious.¹⁹

Plasma

As an emergency measure in *hemorrhage*, in the *prevention of shock* and in *shock*, plasma and serum have been advocated by a number of workers.²⁰⁻²³ Although whole blood is the best restorative agent in acute hemorrhage unless the hemorrhage is very extensive the loss of erythrocytes is not of serious import and plasma by restoring the blood volume is an effective agent in preventing and combating shock. However the plasma or serum per se is not sufficient and whole blood should be given as soon as it is available. Jane way⁸ found in a series of patients with bleeding peptic ulcers whose hemoglobins were 50 per cent or less that the use of plasma alone was frequently accompanied by reactions and by a fall in blood pressure. The amount of plasma to be used depends entirely on the severity of the condition; in some instances 250 cc. is sufficient at times as much as 2500 cc. may be required.

Plasma has been used extensively for the treatment of *burns*. The difference between burn shock and shock due to other types of trauma is that in the former the degree of hemoconcentration is greater. Harkins¹⁰ states that 60 to 75 per cent of the deaths in burn cases are due to shock. We feel that these deaths are to a large extent preventable by the judicious use of plasma instead of overburdening the circulatory system with whole blood and drowning the body tissues with overdoses of glucose and saline.

The *advantages* of plasma are that it may be prepared, tested and stored in large quantities for long periods without deterioration. It may be transported easily and administered simply, requiring no particular care such as refrigeration and washing. As interval therapy, plasma prevents and combats oligemia and acidosis and maintains the plasma proteins and blood pressure so that when whole blood is subsequently given its purpose is to overcome secondary anemia rather than shock. The use of plasma enables prompt surgical treatment, avoiding the delay of awaiting whole blood transfusion. *Liquid plasma* is most readily administered but offers the least resistance to bacterial growth. *Frozen plasma* preserves the various protein elements but must be rapidly thawed out at 37° C. *Dried plasma* is most conveniently transported but requires expensive equipment for large scale production and must be regenerated with distilled water.

Physiologic Sodium Chloride Solution

In considering the use of intravenous agents other than blood in patients in whom there is a disturbance of water balance, one must evaluate the degree of hydration, the electrolyte balance and the nutritional state.¹⁷ The body water is classified as intracellular and extracellular, the latter as interstitial and intravascular. The interstitial fluid is three times as large as the intravascular. During extracellular water loss the plasma volume up to a certain point is maintained at the expense of the interstitial fluid but beyond this point the plasma volume diminishes with resultant hemoconcentration. Thus hemoconcentration with reduced plasma volume indicates a serious reduction in extracellular fluid.

The loss of electrolytes occurs chiefly through vomiting. The chloride ion is the principal electrolyte lost with gastric juice and if this loss is great, hypochloremia and alkalosis result. Sodium is lost principally with pancreatic juice and bile and acidosis may result from loss of these juices. When chlorides are lost only small amounts of fluid are necessary since water and electrolyte retention are greater. When sodium is lost larger amounts of fluid may be given since neither water nor electrolytes are retained, obviating the danger of retention edema. In the dehydrated patient who is

acutely ill the use of sodium alone is insufficient since the blood may become more concentrated. Adrenal cortex will help fix the sodium in these cases. In hypoproteinemia where there is already a fixation of sodium chloride in the tissues the use of adrenal cortex is contraindicated. In marked dehydration the renal function is often impaired and the use of large amounts of salt solution is associated with edema. In such cases glucose should be used since it causes an increased renal flow and increases the plasma volume.

The routine use of large amounts of saline solution parenterally has resulted in degeneration of the heart muscle and kidney and in edema of the lungs.⁴ Collier and his co-workers found that when 5 per cent dextrose in saline was given to surgical patients all of them developed edema of the lower back and ankles whereas when the solution was changed to 5 per cent dextrose in distilled water the retained fluid was promptly excreted. The common practice of using physiologic saline in shock accompanied by loss of plasma must also be deprecated. Although the infusion of plasma produces a temporary rise in blood volume with an apparent improvement in the patient not only is this of short duration but it is accompanied by such a marked dilution of the blood that the serum protein is reduced to an edema level. The saline leaks out of the blood stream not as such but as diluted plasma thereby actually increasing the rate of protein loss. As a consequence of the loss of protein the osmotic pressure of the blood is lowered permitting the loss of fluid into the areas of injury and throughout the viscera accentuating the pathologic changes therein.⁶

Other Agents

Gum acacia and *adrenal cortical hormone* have been advocated at intervals by some for the treatment of shock. *Gum acacia* is considerably less effective than blood or glucose and much more dangerous. Amberson⁹ has listed the objections to *acacia*. The sedimentation rate of the red blood cells is greatly increased and the cells are coated with gum thus hindering the diffusion of oxygen. The osmotic pressure is not maintained for more than forty-eight hours since the *acacia* leaves the blood stream rapidly. The gum is fixed in

the liver and this retention results in a diminution in the concentration of plasma proteins. Antigenic reactions are frequent.

Adrenal cortical hormone has been of some value in the prevention of fluid loss in cases of severe burns. Rhoads³⁰ and his co-workers believe that the capillaries may regain their normal permeability more rapidly when the patient is given adrenal cortical hormone.

CONCLUSIONS

1. The requirements and characteristics of the individual patient must be considered in order to obtain the most beneficial results from the use of blood and blood substitutes.

2. A knowledge of the advantages and limitations of the various kinds of fluids used intravenously is essential for their judicious use.

3. Treatment for shock should be instituted before the classical clinical picture is manifest.

4. Changes in the blood volume and hematocrit reading are indicative of impending shock.

5. Whole blood is the ideal replacement for hemorrhage; however, plasma is extremely useful as interval therapy until whole blood can be obtained.

6. In the replacement of fluid lost by the body, the best results are obtained when an equal amount of the same fluid is used.

7. The routine use of physiological saline should be avoided except when specifically indicated since it may produce or aggravate tissue edema.

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THE TREATMENT OF INFECTED WOUNDS

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THE treatment of traumatic and infected wounds received a tremendous stimulus from studies carried out during World War I. Among these two contributions stand out the Carrel-Dakin technic in the treatment and prevention of infections and the radical debridement of wounds to remove nonviable tissue together with bacterial contamination. These additions have stood the test of time and now well into World War II we can depend upon them. During the intervening years new methods have been developed particularly the use of chemotherapeutic drugs. Several of these are well established others entirely new.

We wish to discuss these various treatments in order to provide a basis for their evaluation in surgical infections.

CARREL DAKIN'S SOLUTION AND OTHER CHLORINE LIBERATING MIXTURES

For two decades Carrel Dakin's solution has been used in the treatment of infected wounds. The results obtained have in general been excellent. Fresh wounds recently infected and old chronic suppurative processes have responded well. The slow liberation of chlorine in a wound containing necrotic tissues inhibits the growth of bacteria, kills many of them and with the continued flow of the solution literally washes out the wound, freeing it of infected foreign body material.

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It is the mechanical and chemical effect that cleanses the wounds. In chronic suppuration this facilitates healing after eliminating the infection. In fresh wounds it prevents infection.

Fresh wounds to be treated with Carrel-Dakin's solution must after debridement and reparative procedures have small pliable perforated rubber tubes so placed that all interstices of the wound will have a continual flow of the solution. The tubes are best held in place by gauze loosely packed in the wound. The skin is protected by vaseline gauze. Immobilization is essential for success. The treatment should be continued until bacterial cultures show no hemolytic streptococci and smears reveal a minimal number of bacteria eight hours after discontinuing the solution. During the first World War many wounds were closed by delayed suture after using this method to disinfect them.

The use of Carrel-Dakin's solution requires a great deal of effort and meticulous attention to detail. Many other chlorine liberating substances have been brought out in an attempt to diminish the work required. None of these are as satisfactory as Carrel-Dakin's solution. This solution deteriorates rapidly. It should be prepared daily and kept in colored bottles at low temperature. Elaborate delivery systems of glass and rubber tubing that require constant and expert attention must be used. The skin must be protected. The necessarily frequent dressings and adjustments of tubes may be considered in the light of the Orr¹ and Trueta reports actually to interfere with the healing process. The many satisfactory results obtained with chlorine liberating solutions however indicate that they will continue to be used especially in massive wounds with extensive slough. A combination of sulfonamides and chlorine liberating mixtures such as azochloramide and sulfadiazine as proposed by Schmiles² has shown a synergistic action that promises a high degree of efficiency both as a bacteriostatic and bactericidal agent.

THE SULFONAMIDES

Principles of Action—The action of the sulfonamides is bacteriostatic.³ They do not destroy bacteria but they inhibit their growth and multiplication. In overcoming infection or

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cocci colon bacilli and the anaerobic organisms. The first three named are it seems ever present they are aerobes they grow and increase throughout the wound and invade the adjacent tissue. The anaerobic streptococci and the gas producing bacilli and spores will multiply only under special conditions usually these include a diminished oxygen supply and the presence of necrotic muscle tissue. The results of the bacterial action of the aerobic organisms often provide the conditions favorable for the growth of anaerobes and thus the two bacterial groups are in a sense synergistic.

Importance of Debridement—The actual bulk or amount of necrotic tissue is of importance because it serves as an excellent culture medium for the aerobic as well as anaerobic bacteria. The disintegrating organic material inhibits or neutralizes the bacteriostatic action of the sulfonamides and if the amount of necrotic material is great enough it will prevent the sulfonamides from reaching the bacteria. Hence the removal of necrotic organic material is essential for it not only reduces the medium for the aerobes but also tends to prevent the establishment of conditions favorable for anaerobic growth.

Factor of Solubility—The solubility of the sulfonamide drug may determine how much of it will be utilized and to a degree how quickly. The ideal drug requires that it go into solution readily enough to be immediately bacteriostatic but slowly enough so that it will not be taken up by the viable tissue and removed quickly from the wound. Because the sulfonamides are bacteriostatic and not bactericidal if they are totally removed the infection is delayed rather than cured. The continuation of the bacteriostatic action locally and systemically should see the eventual cure if the normal protective mechanisms of the tissues to overcome an infection are present.

Dosage and Administration—In the treatment of traumatic or contaminated fresh wounds the local application of the drug may prevent infection. Because of its solubility sulfanilamide is the drug of choice. It may be used in amounts up to 5 gm. in a single wound and if there be multiple wounds the total dosage should not exceed 10 gm. For systemic administration sulfathiazole and sulfadiazine are preferable because

of the few associated toxic reactions and the ease with which they are administered. Both may be given by mouth. Four gm. in an initial dose followed by 1 gm. every four hours should establish and maintain a satisfactory therapeutic blood level of 6 to 10 mg. per 10 cc. If oral administration is not feasible they may be given intravenously in 5 per cent solutions of the sodium salts in sterile water. The subcutaneous administration of these drugs has lost previous popularity because of the local irritation they produce. These general instructions may be followed in the treatment of established infections.

During the administration of the sulfonamides care must be exercised to note any of the toxic reactions that may occur and to discontinue the drug if they be of possible seriousness. A blood level determination should be made every two or three days and used as a guide for dosage. A fluid intake should be maintained that will result in a urine output of at least 1000 cc. daily. Examination of the urine for red blood cells and albumin should be repeated daily. If the infection is severe and accompanied by an elevation of temperature the drug should be continued for four or five days after the temperature returns to normal. The local appearance of the wound if it be unsatisfactory may indicate the further use of the drug. In instances where the infection has been well established before treatment is instituted it is a good practice to secure a therapeutic blood level of the drug before surgical intervention is attempted.

ZINC PEROXIDE

In infections by anaerobic nonhemolytic streptococci zinc peroxide as demonstrated by McInerney⁵ is specific. Anaerobic infections are in all probability far more frequent than generally realized owing in large part to deficiencies in the making of bacteriological cultures. These organisms are common inhabitants of the oral cavity, the gastro-intestinal tract, the female genito-urinary tract and the skin surface. A pathogenic role is assumed by this group of organisms wherever they flourish as in traumatic or surgical wounds with necrotic tissue, a diminished blood supply and a lack of oxygen.

Wounds about the mouth the abdomen and near the but rocks in particular those communicating with the rectum are most frequently infected by the anaerobic streptococcus Sandusky Pulaski Johnson and Meleney have in a recent study of 170 consecutive infected wounds on a general surgical service demonstrated nonhemolytic streptococci in twenty nine on anaerobic culture This indeed emphasizes the urgent necessity for culturing all wound infections for anaerobic organisms

Zinc peroxide is a whitish crystalline powdered material that under proper conditions in a wound slowly liberates oxygen and inhibits the growth of anaerobic nonhemolytic streptococci The action is indirect it is bacteriostatic rather than bactericidal Zinc peroxide is activated by heating for four hours at a temperature of 140° F Once activated it should be kept in air tight containers and should be efficacious for eight months to a year It is mixed with sterile water to form a thin paste which will permit its flowing into every possible portion of a wound If the wound is open it is well to fill the entire cavity with the material It is covered with a layer of moist gauze There is then applied a rubber dam or vase line gauze covering in an attempt to prevent drying of the zinc peroxide which tends to cake in the wound dry it is of little value The wound must be kept moist Wounds should be dressed once in one or two days the dried zinc peroxide removed the wound flushed with saline and more of the material introduced Immobilization facilitates the normal processes of wound healing

Sometimes it is difficult to introduce zinc peroxide into deep wounds and for these in particular great care is needed to insure having a thin mixture which will readily flow into the interstices and furthermore the protection of these wounds by means of coverings which will keep moisture and oxygen from escaping is important

Extending infections especially those of an extensive nature that begin most frequently upon the abdominal wall and sometimes reach great proportions before they are recognized require more than simple application of the zinc peroxide These must have excision of all necrotic and infected

tissues This is a laborious task which requires meticulous skill and unfaltering courage Then with excision complete the resulting wound is treated with zinc peroxide

The anaerobic nonhemolytic streptococci are frequently to be found in mixed infections with fusiform bacilli and spirochetes the human bite is the most common example These organisms are most difficult to rid the wound of and are extremely resistant to those measures that enable us to overcome infections of an aerobic nature Here again removal of necrotic and infected tissue followed by the proper use of zinc peroxide accomplishes excellent results

There is a definite place for zinc peroxide in the prophylaxis of wound infection as has been repeatedly pointed out by Meleney and his co workers If a wound is contaminated with anaerobic organisms or if its location adds to the likelihood of its being contaminated then the introduction of zinc peroxide into the fresh wound and leaving it open may avoid serious infection

Zinc peroxide to be of true value must according to Meleney (1) be an active preparation (2) come in close contact with every part of the infected surface and (3) be kept wet

DIAGNOSIS AND TREATMENT OF GAS GANGRENE

Gas gangrene is usually the result of growth of three anaerobic organisms *Clostridium welchii* *Cl. septicum* and *Cl. oedematiens* These organisms are frequently carried into deep traumatic wounds by fragments of clothing Fortunately gas gangrene is relatively rare in ordinary surgical wounds but large areas of necrotic muscle in deep wounds provide ideal anaerobic conditions for the growth of these organisms

The diagnosis of gas bacillus infection in a wound is dependent upon bacteriological examination The presence of a copious watery dirty discharge with a sweet musty odor is highly suggestive This with the demonstration of gas in the tissues by x ray may justify the diagnosis for therapeutic purposes In traumatic wounds the early rapid bacteriological examination is of tremendous value

The best preventive means are (1) debridement (2) sul

fonamide therapy and (3) gas gangrene antitoxin. The recommended dosage of the last named is 300 international units of *Clostridium welchii* 1500 I U of Cl septicum and 1000 I U of Cl oedematiens.

In treatment the most consistently good results have followed early operation with the excision of all infected muscle the wound being left completely open. If the infection is rapidly progressive amputation should be done. The wounds are best treated with the sulfonamides and zinc peroxide. Antiserum therapy is insisted upon by many and consists of a constant intravenous drip of 100 cc serum diluted in 1000 cc of normal saline. The value of x ray therapy is as yet not completely established and we would be reluctant to discard those measures in which we have confidence for those we regard as uncertain.

X RAY THERAPY

Kelley and Dowell⁷ have recently published an account of their experiences over a period of twelve years with the treatment of gas gangrene or *Welch bacillus* infection by x rays. The results of these workers are very encouraging. They have collected reports on over 200 patients with less than a 10 per cent mortality. They advocate immediate treatment of infection with a dosage of 100 roentgens repeating this daily until the infection is overcome. In their estimation the use of the sulfonamides is contraindicated as is debridement and amputation. The cases reported by these men however in many instances lack adequate bacteriological data for the establishment of diagnosis.

Mowat⁸ in England reports that he has been favorably impressed by his results from x ray treatment in a few cases of what he believes were gas bacillus infections. His report also lacks specific data.

PENICILLIN

Fleming⁹ in 1929 noticed that a mold later identified as *Penicillium notatum* caused lysis of staphylococcus colonies when growing together on agar plates. From the mold he isolated the active principle containing this property and named it penicillin. This first crude preparation has been

purified until it is 1000 times as strong as that first used¹¹ and also has been produced in crystalline form¹¹ At present the exact chemical composition is not known The mold *Penicillium notatum* is easily grown in quantities and by methods of extraction gives rise to large yields of the active principle which may be assayed Although nontoxic for man penicillin is extremely deadly for bacteria

This new drug has a remarkable effect in vitro on many gram positive organisms both aerobic and anaerobic and in addition the gonococcus and meningococcus are also affected The gonococcus shows complete inhibition of growth in 1 2 000 000 concentrations of penicillin while in a concentration of 1 1 000 000 the same is true of the meningococcus staphylococcus streptococcus and anthrax tetanus and Welch bacilli It is not clear how susceptible the gram negative organisms are to this drug but at least they are more resistant than the gram positive bacteria Although extremely effective in vitro for gas producing organisms penicillin is probably ineffective against the tubercle bacillus and may show little activity for the anaerobic streptococcus¹ which responds so well to zinc peroxide Penicillin has been shown to be effective against both parent and sulfonamide fast pneumococci in mouse infection experiments¹ Two strains of staphylococci however have proved resistant to it¹

Penicillin may be either bacteriostatic or bactericidal in action depending upon experimental conditions¹¹ It causes no lysis of the organisms The concentration necessary to kill is comparable to that of gramicidin and tyrocidine rather than the sulfonamides The sulfonamides cause only a slowing up of the rate of growth but penicillin also causes death of the organisms By cultivating staphylococci in the presence of penicillin they become resistant and after sixteen weeks are able to grow in a concentration 1000 times stronger than that which inhibited the parent bacteria The active agent is readily filtrable and is not destroyed by boiling for a few minutes

Despite powerful antiseptic properties penicillin is non-irritant to tissues At concentrations of 1 500 it does not embarrass leukocytic activity in vitro Since the effect of chemotherapy depends largely upon leukocytic activity this

is particularly important. As penicillin is less toxic to leukocytes than the sulfonamides it should make an admirable local application. Applied locally to the brain in 1:1000 concentration the drug has no ill effect. The activity of penicillin is in no way interfered with by serum, blood, pus, dead tissue or peptone.

Penicillin is *nontoxic* and can be administered by any route. It is rapidly destroyed by acid and therefore large losses are to be expected with oral administration. It is absorbed from the intestinal tract, subcutaneously, intraperitoneally, intramuscularly, and can be given intravenously. Elimination is by way of the kidneys in an active form. A portion of the drug is inactivated in the body and does not appear in the urine. Owing to its rapid elimination by the kidneys frequent or constant administration is necessary. A continuous intravenous drip has been the simplest as well as the most useful form of administration. Oil suspensions and dry pellets have been used with success. Several methods have been employed to get the active substance past the stomach where it is destroyed by acid, such as neutralizing the acid, placing the compound in capsules, or putting it into the duodenum by way of a tube. As penicillin is inactivated by feces there is little or no effect following rectal administration. Locally the drug can be used even in the eye.

Protection of animals experimentally infected by lethal doses of streptococci and staphylococci has been dramatic. Mice are protected against 1,000,000 times the lethal dose of hemolytic streptococci given intraperitoneally by 1.5 mg. of penicillin injected subcutaneously.¹¹ This treatment has been found to be effective if started eight hours after infection.

So far few clinical results have been reported. When used in ten cases by Florey and his co-workers¹⁰ a favorable therapeutic response was obtained in each case. In five patients with staphylococcal and streptococcal infections penicillin was given intravenously; to one baby with a persistent staphylococcal urinary infection it was given by mouth while it was applied locally to the eye in four patients with eye infection.

With crystalline preparation of penicillin one may expect synthesis of the chemical compound. With adequate quan-

tities for research and clinical trial there may be opened an entirely new field of chemotherapy. At this time penicillin offers a most promising agent for the treatment of infections but it is entirely in the experimental stage.

GRAMICIDIN

It has been known for many years that certain bacteria inhibit the growth of others in a selective manner. The presence of one bacteria may greatly accelerate the growth of another. With these facts in mind Dubos¹² attempted to isolate an active principle produced by one bacterium to be used in treatment of infection caused by others. In 1939 by the use of peptone cultures of the aerobic sporulating organism *Bacillus brevis* isolated from the soil he produced a soluble principle extremely toxic to gram positive bacteria. This he called *tyrothricin*. Tyrothricin has in turn been split into two active parts, *gramicidin* and *tyrocidine*. These latter substances differ in their chemical composition and also their action on bacteria although both are extremely active against gram positive organisms.

All three compounds are active against gram positive bacteria. In addition tyrocidine is active against some gram negative species. Gramicidin is completely inactive against gram negative bacilli but is moderately active towards the meningococcus and gonococcus.

In studies using tissue culture technic gramicidin has been found to be more effective than tyrocidine against most of the gram positive bacteria studied.

In addition to being active against bacteria these substances are also toxic for man. When injected intravenously they are extremely dangerous and cause death for dogs or mice when even very small amounts are used. In vitro there is a powerful hemolytic action on red cells from human rabbit or sheep sources. At present it is not proved that this property is not present in each of these compounds. In spite of the hemolytic effect there is no evidence of damage to tissues or obvious effect upon the leukocytes.

The effect of gramicidin is inhibited only to a small extent by serum, tissue extracts or peptones. Administered orally it fails to damage or produce lesions of the gastrointestinal

tract and locally it accelerates wound healing. It is not toxic applied locally to wounds or mucous membranes. Injections of large amounts into closed cavities of the body are accompanied by both local and general toxic effects.

Gramicidin given orally although not toxic is ineffective.¹⁴ When given by mouth to animals harboring susceptible organisms in the gastro intestinal tract there is no effect even when 160 times the in vitro killing dose is given. However when mice are infected intraperitoneally with large numbers of virulent pneumococci it is found that gramicidin given subcutaneously will protect them.¹⁵ It gives protection even when administered several hours after injection of the organisms.

The clinical use of gramicidin in twelve cases in which gram positive bacteria were present¹ showed no damage to tissue and marked beneficial effect in most instances with increased wound healing and no evidence of toxicity. In another series of fifty eight localized infections¹⁶ consisting of ulcers caused by the *Streptococcus hemolyticus*, *Staphylococcus aureus* and *Streptococcus faecalis* it resulted in sterilization and healing of the wounds.

Although gramicidin has no effect when administered orally it is deadly when given intravenously and had best not be used in the closed cavities of the body. When used in local wounds infected with gram positive organisms it shows great promise. It may eventually be used to irrigate infected cavities but it cannot be allowed to come in contact with the blood stream. At present the use of gramicidin must be regarded as entirely experimental.

COMMENT AND SUMMARY

The treatment of infected wounds is ever changing and new substances are being added to our therapeutic armamentarium. The chlorine liberating mixtures have been widely used over the past twenty years and by and large are credited with good results when properly employed. Zinc peroxide has been demonstrated by Meleney to be specific for the anaerobic nonhemolytic streptococcus. The popular drugs of the day are the sulfonamides but a more critical evaluation of their worth is indicated lest they be forced to

carry the burden of inadequate surgery and fall into disfavor. The sulfonamides nevertheless are in many respects the most ideal chemicals yet available for the treatment of the common infections. It must be remembered that success is dependent upon direct contact with the offending bacteria and that pus, necrotic tissue and foreign material tend to prevent this contact. Furthermore the lack of a demonstrable specific effect upon the anaerobic bacteria requires that necrotic muscle and other substances conducive to a diminished available oxygen be removed. There remains therefore the principles of debridement and the prevention of tissue ischemia in treatment of all traumatic wounds. If these are always fulfilled much leeway remains in the later treatment whereas if they are not adhered to the best methods are doomed to failure.

The introduction of any new method or material of promise in the treatment of infection is accompanied usually by renewed interest in the subject. Under such circumstances greater attention to all details of treatment should result and the total of these make for success. Penicillin may on the basis of its present limited clinical application become the outstanding substance in the treatment of infection. It lacks toxic effects upon tissue and is lethal for a large number of bacteria in extremely low concentrations. The production of this material however because it is the product of bacterial growth is tedious and difficult. It remains for its production to be increased before extensive clinical investigation can be undertaken.

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SURGICAL MANAGEMENT OF TRAUMATIC LESIONS OF THE ARTERIES

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THE first World War was a stimulation to vascular surgery and the contributions made at this time exceeded greatly those in any similar surgical era. Surgeons have always been interested in the possibilities of operating on the vascular system but the dangers and the frequency of failure relegated the work to the hands of the few masters such as Matas. Surgical history is replete with the names of such technicians as John Hunter, Bilroth, Trendelenburg, Milne, Abancow, Moynihan, Murphy, Halstead, Carrel and others who were interested in the vascular system but while great steps were taken in the understanding of the physiological problems little clinical success could be reported. With the coordination which developed in surgical work and the allotment of these patients to specialists in various fields during the World War the right men and the opportunities were combined and in the after years the residual problems of aneurysm, ulcerations and the like could be handled more clearly from this service experience. In the final analysis the fate of the individual and any of his parts depends entirely on the maintenance of the blood supply. Particularly is this true in traumatic wounds where the decision as to amputation and level will depend upon the maintenance or failure of circulation in a high percentage of instances. We will consider in this discussion those lesions related to trauma both direct and indirect as well as the effect of elements and environments on the circulatory system.

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This war, with its multiplicity of scattered fighting zones ranging from tropics to the arctic will bring the vascular problem more to the front. Nonacclimated men must live and exercise in temperature extremes to which even natives succumb. We must expect therefore, to see an increasing number of complications both in military and later, in civil life and be prepared for them. A high toll in the armed services will be exacted by lesions in this field. Already one major battle on the Russian front has been decided by a sudden disabling of several divisions of Rumanian troops not prepared by acclimatization for service before freezing Lenin grad and a clever Russian general who took advantage of the simultaneous temperature and troop change carries a Marshal's baton today. We are but barely aware of the medical implications of this war as yet.

CLASSIFICATION AND INCIDENCE

OUTLINE OF ARTERIAL DISEASES IN RELATION TO TRAUMA

- 1 Injuries to arteries
 - (a) Lacerations
 - (b) Contusions
 - (c) Thrombosis
- 2 Spastic lesions of arteries
 - (a) Raynaud's syndrome
 - (b) Traumatic segmentary arteriospasm
 - (c) Frost bite
- 3 Aneurysm
 - (a) Arterial
 - (b) Arteriovenous
- 4 Occlusive arterial diseases
 - (a) Arteriosclerosis
 - 1 Without diabetes
 - 2 With diabetes
 - (b) Thrombo angitis obliterans

In discussing the arterial system we must consider those diseases which affect the arterial system primarily and which with the addition of exposure or trauma may precipitate an occlusion and those lesions occurring in a vascular system previously normal. Examples in the first category are those damaged walls due to one of the occlusions (see outline) or with an underlying tendency to spasm as in Raynaud's syn-

drome and in the second category those in which as a result of direct or indirect trauma or of exposure of traumatizing environmental conditions previously normal blood vessels become pathologic either temporarily or permanently.

Some idea of the incidence of occlusive arterial disease has been obtained by a recent study we have completed of 536 people over forty who had been working for fifteen years or more. These findings indicated that 46.3 per cent of the men and 19.9 per cent of the women showed arterial impairment either by arteriosclerotic changes on x-ray or subnormal oscillometric readings (less than $\frac{1}{8}$ oscillation in only one foot). This sex difference in the evidence of arteriosclerotic conditions was further emphasized by the demonstration that while 43 per cent of the men had calcification on x-ray study only 15 per cent of the females had it and of the advanced calcifications (beading, plaques and so forth) while 78 per cent of the males showed this change none of the women had it. The fact that sclerotic changes occur in such a high percentage without symptoms was further demonstrated by the revelation that only 19 per cent of those with calcification showed any abnormality in the oscillometric readings. This point is made to emphasize that nearly half of all the active men over forty have an underlying arteriosclerotic change which four times out of five is subclinical but must be considered when severe aggravation may develop.

INJURIES TO ARTERIES

Lacerations

When a major wound is encountered where obviously an artery has been injured the first treatment is to stop hemorrhage and in most instances this is best done by applying a tourniquet. In the application of the tourniquet certain anatomical points must be remembered.

First aid

1. Apply the tourniquet above but as close to the wound as is feasible.
2. A pad placed directly over the artery will increase the effect.
3. The hour and the minute of the application of the tourniquet should be marked on a tag on the tourniquet.

- 4 Where there will be considerable time intervening between the application of the tourniquet and the entrance of the patient to the operating room the tourniquet should be loosened at least every hour and then re applied
- 5 Clean and if possible sterile dressings should be applied to the wound and the part splinted before moving the patient This is fundamental

In the dressing room (Depends upon equipment)

The clothing etc surrounding the wound should be cut away the area surgically prepared and if feasible the vessels clamped with a sterile hemostat and the tourniquet removed

In the operating room (Early arterial lacerations)

Careful preparation of the wound site with cleansing complete debridement and so on is fundamental

Studies by Halstead Matas Babcock Murray and Best as well as our own experiences show that many more lacerated arteries can be sutured than was thought possible If a fair blood flow can be demonstrated from the proximal end of the artery repair is worth considering even if complete division has occurred Thrombosis may be present in the traumatized vessel and the thrombus should be removed with a forceps if possible A portion of the clot may break off and remain in the vessel It may be necessary to remove this part with a corkscrew as in embolism A simple corkscrew may be made by wrapping a silver or steel wire around a probe and this can be introduced into the clot in corkscrew manner and with its rapid withdrawal the blood flow restored At times ingenuity in the removal of the thrombus is necessary Suction postural changes and even manual milking may be required to remove the clot

Primary suture may now be made with minute needles and fine arterial silk care being taken to avoid placing the needle through the intima Where available a small strip of fascia or muscle will reenforce this suture line The technical points in arterial suture are shown in Figure 79 It is surprising to find how little suturing is necessary The pressure on the arterial wall follows the hydrostatic law of being in

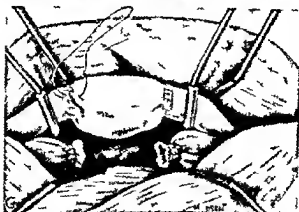
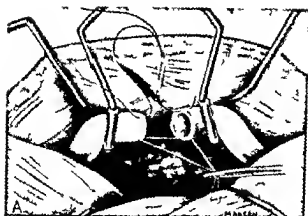


Fig 79—Suture of lacerated arteries *A* End to end anastomosis. Notice minute needle and suture do not enter lumen. *B* Surrounding fascia muscle used to reinforce suture line. *C* Where artery lumen deficiency exists

versely proportional at any point to the rate of flow. Where a segment of vessel has been destroyed defects up to 2 inches have been corrected by stretching the artery or rerouting it. Since many of these injuries occur at or near a joint a flexion of the joint will add to the amount of vessel available.

When the injury to the artery has not involved a contiguous vein a section of the vein may be utilized as a transplant to repair a segment of destroyed artery. It is surprising

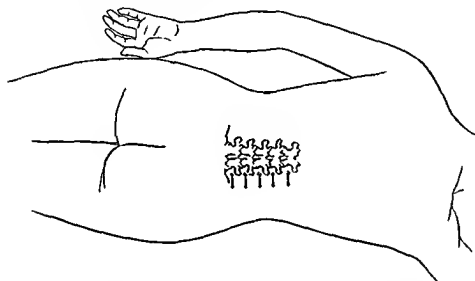


FIG. 80.—Sympathetic nerve block for lower extremity. Interspaces 4 cm from the midspinal line are outlined. The needle is introduced 4 cm and then the direction changed slightly medially and inserted 4 cm to the sympathetic ganglion.

to see the balloon like vein shrink down to the size of the arterial column and in time this vein will become the same thickness as the surrounding artery. After such a procedure all these patients should receive a sympathetic nerve block as the surgical procedure tends to place both the operative site and the collateral vessels in spasm. These nerve blocks after some experience are technically simple and can be repeated (Figs 80-81). Heparinization is also carried out routinely.

vein transplant at times can be inserted. Balloon like vein contracts to the size of the arterial flow when circulation is resumed. Heparin and dicoumarin are used after all arterial surgery.

ARTERIAL LACERATIONS—LATE—General preparations like those described are made. If arterial flow is obtained after the removal of all clots, primary suture is attempted. If no arterial flow is present, resection of the artery and its ligation should be performed. The accompanying vein should



Fig. 81.—Sympathectomy, block for upper extremity (stellate ganglion). The needle is introduced at the angle of 45 degrees to the angle made by the bifurcation of the mid-thoracic and metacromial line. The needle is introduced until the vertebral column is encountered and placed posterior to the vertebral artery junction of the vertebral artery.

also be resected. It has been found that simple ligation of the iliac artery will result in gangrene of the extremity in approximately 18 per cent of cases. Resection of the accompanying vein will reduce this to approximately 8 per cent. The reason for this difference is that resection of the accompanying vein

reduces the rapidity with which the blood is returned from the periphery. Where blood is reaching the extremity through small collaterals only its return is thus equalized and a longer time is provided for the nutrition of the extremity. Sympathetic nerve block should be done in all of these late cases and all should be treated as occlusive arterial diseases.

Contusions

Injuries of a bruising character may be so severe that while the vessel has not been cut its function may be interfered with as a consequence of the contusion and resulting thrombosis. The same syndrome may be set up as that which follows a peripheral embolism. The remainder of the vessel and its collateral supply go into a spasm and the leg becomes marble white paralyzed numb distally from the injury. Subsequently mottling appears then duskeness and if the condition is not relieved gangrene eventually develops. To aid the patient therapeutically the physiology must be understood. The spasm is physiological and is nature's effort to prevent massive thrombosis in the vessel as would result should it and the collateral vessels remain open in the presence of the reduced arterial circulation. Surgical intervention in these patients is dangerous and usually ineffective. Efforts should be confined to stimulation of collateral circulation as outlined under the therapy of occlusive arterial disease and sympathetic nerve block should be repeated whenever necessary.

SPASTIC LESIONS OF ARTERIES

By spastic conditions is meant the temporary spasm of a major vessel which may be due to functional causes, traumatic injuries or environmental or temperature changes.

Raynaud's Syndrome

The classical lesion of the functional group is the Raynaud's syndrome in which a spasm of unknown etiology develops apparently as a result of stimulation or overactivity of the sympathetic ganglia. Certain of these lesions become occlusive and gangrenous. Surgical treatment is reserved for

those who will not respond to any medical treatment. Surgical treatment consists of sympathectomy and local amputations for gangrenous areas late and after collateral circulation has developed. It is our belief that only those intractable cases of Raynaud's disease that show a marked improvement and a skin temperature rise of 8° to 17° F. after sympathetic nerve block should be considered for sympathectomy.

Traumatic Segmentary Arteriospasm

This group of patients consists of those in which a segment of the artery develops a spasm when subjected to repeated or continuous trauma. For example the use of a machine like a comptometer or certain pedal machines operated rapidly with toe pressure may so traumatize end arteries as to put them into spasm with resulting ulcerations and gangrene. All therapeutic measures fail unless the causative trauma is removed. Surgical treatment includes draining of secondary infections, excision and saucerization of ulcers and amputation when gangrene has developed and demarcation is complete.

Frost bite

This condition is described also as immersion foot, shelter foot, trench foot and pressure leg. Pathologically the lesions are the same and result from continued spasm over a considerable time and eventual occlusion with chemical changes in the circulatory media of the extremity. Experience from observation and reports of patients taken from the sea where they have been in open boats for days or weeks and particularly that group rescued after torpedoing in the North Atlantic has revolutionized our conception of therapy in these cases.

In the consideration of *treatment* these lesions may be divided into three classes:

1. *Mild cases* (first degree) where there has been only erythema but no skin break or tissue destruction. Treatment here is reflex dilatation by gradual body warmth and the use of hot drinks, particularly whiskey, mild active motion of the part and in some cases a sympathetic nerve block.

2 *Moderately severe cases* (second degree) where the greatest danger is skin breaks with sloughs and where recovery and retention of the limb will depend on the therapy. In addition to the general warmth and hot drinks a sterile surgical dressing is applied with great care to prevent infection in the limb. The extremity is kept cool by the use of electric fans and at times ice. Surgical intervention in the form of local amputation is performed only late and then after demarcation is entirely complete.

3 *Severe cases* (third degree) While shock is combated by gradual warming of the rest of the body the extremity is kept refrigerated approximately ten ice caps being applied to it. All local lesions are surgically dressed and kept sterile and in the absence of infection no amputation is performed except late and after self demarcation is complete. Only in the presence of an uncontrolled infection is this routine varied. Refrigeration of these extremities has permitted more men to walk again or to have local excisions only than therapy of any other type previously reported.

ANEURYSM

Aneurysms acquired as a result of trauma are of the arterial and arteriovenous types and follow most often gunshot stab or shell wounds.

Arterial Aneurysms

The arterial aneurysms result from a weakening of the wall and after trauma are usually of the so called false type in which surrounding tissues form the confines of the arterial tumor. With time layers of clots may be deposited and in some the aneurysmal contents are mostly laminated blood clots in various stages of resolution debris and a small space for the circulating blood. Calcification is the end result of the resolution process. The symptoms of the arterial aneurysm depend on its size and extent. *Tumor* is synonymous with the aneurysm development but may be masked by surrounding tissues. The same may be true of the *expansile pulsation* and *bruit*. *Pain* is usual owing to pressure on nerve sensitive structures. Pressure on surrounding structures may cause erosion pain or rupture. The so called *Pare sign* (re

ture inasmuch as the collateral vessels on which the circulation of the extremity depends run in and adjacent to the sac and its excision would destroy these important nutrient arteries. Ten patients on whom this procedure has been performed in the last three years have all recovered without the loss of the limb although one patient did lose a portion of the little toe.

Arteriovenous Aneurysm

These fistulas develop also as the result of a lacerating type of wound. Following an arteriovenous fistula certain *changes in the physiology* of the circulation occur. These are (1) a fall in general arterial pressure with a gradual recovery, the systolic pressure being equal or higher and the diastolic lower—thus a greater pulse pressure. (2) an increase in pulse rate. (3) an increase in venous pressure. (4) an increase in the cardiac output depending on the size and location of the fistula. (5) a very temporary decrease in the size of the heart and the artery proximal to the fistula due to the blood flow in the large venous system followed by a gradual dilatation of the heart, artery and vein proximal to the fistula with hypertrophy of the heart. (6) gradual increase in the total volume of the blood. (7) development of collateral circulation around the fistulous site.

It is important to bear these changes in mind because they must be considered at the time of treatment. As a result of the abnormal anastomosis arterial blood is shunted into the venous system and large dilated veins with skin discolorations appear. At times these have been mistaken for ordinary varicose veins. The fistula diverts blood from the extremity and arterial failure of the part to some degree is frequent. The venous blood has a higher oxygen content than is normally seen and its pressure is greater beyond the fistula.

The *surgical treatment* should be delayed eight to twelve months to permit establishment of the collateral circulation. The operation then will be

- 1 Suture and reconstruction of the artery wall through the opened and sacrificed vein. Sections of the vein may be used for reenforcement of the arterial wall.

- 2 Occasionally the fistulous site may be excised and an

end to end anastomosis performed This is the treatment when there are multiple dilated small veins between the artery and the main vein

3 Quadrilateral ligation with or without obliteration In a large proportion of the arteriovenous fistulas ligation of all of the four vessels above and below the sinus is the most practical surgical procedure In some cases the multiplicity of small branches makes this procedure not feasible unless the sinus is obliterated by ligation of the collateral openings and imbrication with or without a muscle implant much as described under Arterial Aneurysm (see Figs 82 and 83) Ingenuity is sometimes necessary and the suture of a section of the surrounding muscle and fused into a sac has been effective in controlling an arteriovenous fistula once in the last year

Efforts to cure weakness or injuries to the blood vessel walls are still being continued The insertion of a coiled spring sclerosing solutions and other foreign materials inside the lumen have not produced the solution for the problem Recent efforts have been directed to stimulate thickening of the wall by irritants It is known that such a substance as cellophane when wrapped around the aorta of a dog will occlude it in a majority of instances On two occasions in aneurysms of the aorta we have wrapped a piece of cellophane around the sac partly constricting it by suturing the cellophane around the vessel To further cause reaction talcum powder another irritant has been sprinkled into the layers of cellophane and around the wrapping It is too early yet to report on the success or failure of these methods but it may be the beginning of a new method of attack in the problem of obliterating a major artery

OCCLUSIVE ARTERIAL DISEASES

By occlusive arterial disease is meant those diseases which by thickening the walls or intima close the arterial lumen They are

- 1 Arteriosclerosis obliterans
 - With diabetes
 - Without diabetes
- 2 Thrombo angitis obliterans

The patient with a disease process which is producing occlusion does not react well to trauma of the direct or indirect or climatic type. In many the blood supply to the part is being carried by such small vessels that even a mild trauma or overexertion may be sufficient to cause arterial failure. The significant criteria in determining occlusive arterial disease are

- 1 A history of claudication, poor healing, frequent infections or diabetes mellitus
- Absence of pulsations in the major vessels (the dorsalis pedis and posterior tibial artery)
- 3 Color changes—redness on dependency and pallor on elevation
- 4 Temperature changes—cold feet with trophic disturbances and unhealthy skin

GENERAL TREATMENT OF ALL OCCLUSIVE DISEASES

I No Open Lesion

- 1 Abstinence from tobacco
- 2 Foot care and hygiene
 - (a) Nail cutting
 - (b) Corns, callus, blisters
 - (c) Shoe pressure
- 3 Avoid overstrain
- 4 Fungous infection treatment
- 5 Vasodilatation and collateral circulation stimulation
 - (a) Baths and soaks
 - (b) External and reflex warmth
 - (c) Postural changes
 - (1) Exercise of the Buerger type
 - (2) Oscillating bed
 - (d) Drugs
 - (1) Typhoid vaccine for thrombo angitis obliterans
 - (2) Pancreatic tissue extract (Depropanex) for arteriosclerosis
 - (3) Glucose and insulin for diabetes
 - (4) Avoid others

II Open Lesion (In addition to the above)

- 1 Absolute bed rest
- 2 Warmth

Soaks

→ Postural changes

Surgical drainage or excision as indicated (Fig 87)

One third of the patients with thrombo-angitis obliterans develop the disease accompanied by acute thrombophlebitis. Surgical treatment of the occlusive lesions is based upon the presence or absence of controlled infection. In the absence

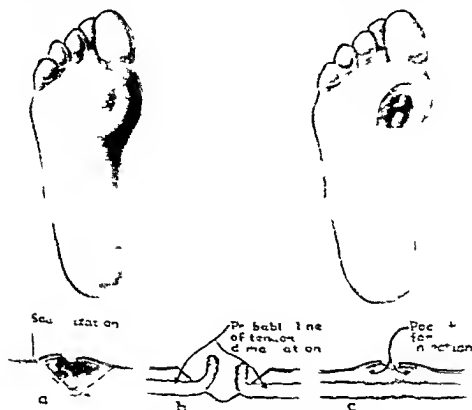


FIG 84—Treatment of arterial ulcer. Shaded area indicates undermining. Excision of underlying tissue with saucerization is necessary. Necrotic tendons are left long until they demarcate.

of infection occlusive lesions are treated ultraconservatively by the prevention of undermining, control of fungous infections and stimulating and permitting complete collateral development and demarcation. Amputation when performed is late, local and, at times, self amputation is preferable. Tendons are left long until they separate. The indication for amputation in the presence of infection is still when the infection reaches the ankle. Patients with vascular disease ac

accompanied by infection present the same problems as those with toxic thyroids—once an optimal time for operation has passed it is impossible to perform the procedure as safely again.

The mortality of amputation in these patients with occlusive disease has been reported from 25 to 80 per cent. Great care in following a set regimen and technic materially reduces these figures. Our mortality figures are shown in the tabulation.

TABULATION

AMPUTATION IN OCCLUSIVE AND MORTALITY OF VASCULAR DISEASE, 1938-194

(At St. Francis Hospital, Post Graduate Hospital)

	Amputations	Deaths	Percentage
Potential arterio- sclerosis and diabetes	28	1	3.5
Thrombo-angi-obliteration	0	4	20.0
Emboli in peripheral	6	0	0
Arterio-venous fistula	5	2	40.0
Arterio-venous fistula	1	0	0
Totals	60	7	11.6
Amputations (refrigeration technique)	13		15.5

The routine which has been established is as follows:

AMPUTATION TECHNIC

I Preoperative

1 General

- Enema, douche, warmth fluids
- Prophylaxis for gas gangrene
- Sulfa drugs
- Gas gangrene antitoxin
- T.A.T.

2 Local

Skin preparation

II Operation

- 1 Speed
- 2 No tourniquet
- 3 No flaps
- 4 No drain
- 5 Light closure, sulfa drugs
- 6 Splint and Buck's extension
- 7 Sealing of dressing

III Postoperative

- 1 General care warmth out of bed etc
- 2 Leave wound alone

IV Anesthesia

- 1 Inhalation—cyclopropane
- 2 Spinal in young patients
- 3 Refrigeration

Indications

Advanced infection uncontrolled diabetes
poor heart etc

Contraindications

Patient who can stand general anesthesia

Technic

See below

After considerable doubt as to the value of its use more experience has convinced me of the value of the *refrigeration anesthetic technic* as a valuable adjunct in reducing mortality and morbidity in the uncontrolled infection cases. Particularly is this true when diabetes mellitus is a complication. Because of the necessity of using a tourniquet with the freezing technic it is reserved for those patients whose chances of surviving a general anesthetic are very poor and where the dangers of the tourniquet are less than the dangers of an anesthesia. The technic consists of

- 1 Prophylaxis for gas gangrene
- 2 Packing of the limb in ice for half an hour
- 3 The application of a tourniquet high in the groin and re-packing in ice
- 4 Amputation of the limb without anesthetic (after thorough skin preparation) from one and one half to three hours later
- 5 Immediate exposure and injection of the sciatic nerve with novocain with its division delayed until the rest of the amputation is complete
- 6 The use of a modified Bucks extension a splint and the sealing of the wound to prevent contamination

It is our belief that *success in major amputations depends on*

- 1 Careful, adequate and complete skin preparation (three soap and water washings) to eliminate the gas bacillus

organisms combined with prophylactic gas gangrene serum and sulfa drugs

- 2 Rapid amputation
- 3 No flaps with the extension skin
- 4 Loose closure—two or three sutures only
Immobolization and splinting of the stump with sealing
- 5 No disturbance of the wound for from ten to fourteen days unless the general symptoms make it necessary

This war will change our conception of the treatment of many diseases and without question the arterial system will be one of the most affected. If we can equal the advances made during and after the last war a real contribution to the more successful treatment of arterial diseases will have been made.

THE EFFECTS OF TRAUMA ON THE NERVOUS SYSTEM*

LEWIS STEVENSON M D

HEAD INJURIES

Immediate Management

Of prime importance in the problem of head injuries is the condition and management of the patient immediately following a severe trauma. He is in surgical shock in many instances and treatment at first is directed only to its alleviation. He is kept warm with blankets and hot water bottles and flat in bed on his side. Some surgeons feel it to be a great advantage to have the head of the bed at least twelve inches lower than the foot (Moore¹) so that bronchial mucus may better drain out of the mouth and thus prevent its inspiration with possible cyanosis and further increase of intracranial pressure or the development of a pneumonia. The patient's pulse and temperature should be recorded every fifteen minutes at first and his blood pressure frequently. These precautions are taken because a slowing of the pulse rate and an increase of blood pressure and a rising temperature sometimes indicate increasing pressure within the head. As Browder and Meyers point out however the classical pattern of signs consisting of steady rise above normal levels of blood pressure steady fall in pulse rate decrease in respiratory rate stupor coma vomiting et cetera which has been held to indicate that the intracranial pressure is on the increase is not met in the present series of brain insults.

From The Department of Pathology, Laboratory of Neuropathology of Bellevue Hospital and New York University College of Medicine and The Department of Pathology, The New York Hospital and Cornell Medical College.

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Therefore it is of little help in determining whether a patient is improving or losing ground (after a head injury) Bleeding points are controlled by sl in clips and a sterile dressing

During the first few hours following injury the patient may be given caffeine sodiobenzoate $7\frac{1}{2}$ grains intramuscularly if the circulation is feeble This may be repeated in four hours Caffeine has a mechanical effect on the brain reducing its volume (Stevenson et al²) and hence relieving the cerebral edema which seems to be present in most cases (Arce) Some surgeons during this early period also give up to 1000 cc of dextrose or a 10 per cent solution of dextrose or sucrose intravenously by the drip method⁵ This like caffeine is given to counteract collapse and the cerebral edema At this point difference of opinion appears with regard to further management (Browder⁶ Dandy⁷ Denny Brown⁸)

Coleman (quoted by King⁹) says for example A large number of fatal cases do not have any rise of intracranial pressure Just why some brains with trauma swell and some do not I do not know but certainly many of the serious cases not only do not have increased pressure but have a condensed brain

Occasionally a patient will have an elevated temperature due to the cerebral trauma and thus requires alcohol sponges every two hours or oftener if the temperature is above 102 F Ice bags should be used for temperature over 104 F Most patients will require side boards on the bed for a time and even further restraint to prevent falling out of bed

Patients with head injuries are often alcoholics so that a threatening delirium tremens may require phenobarbital in 2 grain doses every four hours or 3 drams of paraldehyde by rectum every four hours Ordinary restlessness may often be helped by $\frac{1}{2}$ grain of codeine with 5 grains of caffeine sodiobenzoate intramuscularly

When shock passes off and the systolic blood pressure is over 90 it is the custom to elevate the head of the bed 15 to 45 degrees since this tends to decrease intracranial pressure in most cases Most patients should have 1500 cc of fluid a day and this should be of high caloric value if the patient can swallow If he cannot then he should be given 5 per cent glucose in normal saline slowly by vein or by hypodermoc

lysis After the first forty eight hours he should be fed 750 cc by nasal tube twice a day if he is unable to swallow easily The state of consciousness should be observed and tested frequently and if the pulse drops below 60 or unconsciousness seems to deepen it would be well to give more caffeine intramuscularly and 25 per cent sucrose intravenously (150 cc)

Here further difference of opinion enters especially with regard to *lumbar puncture* as a means of lessening the intracranial pressure and removing blood from the subarachnoid space (Merwath and Freiman¹⁰ and Sands¹¹) If the chemical decompression of 25 per cent sucrose does not improve the patient the lumbar puncture may be done carefully and with a spinal (water) manometer attached to the needle Fluid should be removed slowly through a two way stop cock in the apparatus and the pressure reduced to one half if it is 200 mm of water or over If this procedure helps the patient it may be repeated once or even twice in twenty four hours *If spinal fluid or blood mixed with fluid is escaping through the ear, lumbar puncture should not be done* since this procedure may cause infection of the meninges from reversed flow through the ear

If after forty eight hours lumbar puncture and hypertonic solutions of sucrose have failed to help a patient who seems to have urgent need of decompression then it may be necessary to do a right subtemporal decompression While the patient's caloric and water needs are being cared for shock having been adequately treated we must consider such things as scalp wounds and escape of cerebrospinal fluid through the ear or nose

Scalp Wounds—Lacerations of the scalp should be debrided and sutured preferably within ten hours and this according to King⁹ is best done in the operating room Lacerated scalp wounds not sutured within forty eight hours should probably be shaved foreign bodies removed and the wounds packed loosely with gauze wet in Dakin's solution

Cerebrospinal Fluid Escaping through Ear or Nose—When cerebrospinal fluid is escaping through the ear the pinna and outer part of the canal should be sponged clean with alcohol and the ear covered by a large sterile dressing The patient

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Cerebrospinal Fluid Escaping through Ear or Nose—When cerebrospinal fluid is escaping through the ear, the pinna and outer part of the canal should be sponged clean with alcohol and the ear covered by a large sterile dressing. The patient

should lie on the draining side. This condition usually clears up in a few days.

Escape of cerebrospinal fluid through the nose may require surgical treatment if it persists for more than ten days. In such cases an attempt is made to localize by x ray the site at which the dura has been torn. Then the surgeon through a frontal bone flap explores the region and sutures the tear when possible or inserts a piece of fascia and sutures this to the dura to close the defect.

Neurologic Examination—The neurologic examination should be made as soon as possible to determine whether there is any focal lesion in the brain or spinal cord. X ray of the skull and of the cervical or other portion of the spine will then be made as soon as possible. One must be on the lookout of course for other injuries to bones or other parts of the body outside of the nervous system. The bladder may have to be emptied every eight or ten hours at first and may have to be irrigated twice a day if frequent catheterization is necessary. If the patient has evidence from the neurological examination of focal brain injury such as unequal pupils, hemiparesis (motor or sensory) or reflex changes such as unequal deep reflexes on the two sides of the body or a positive Babinski sign, one must consider what the damage in the brain or cord may be.

Admitting for a moment that a short period of unconsciousness following a head trauma is due to simple concussion or if of longer duration concussion plus contusion and edema, then focal signs mean either brain laceration and collection of blood or fluid over or under the dura or a depressed fracture cutting into the brain or some other lesion which may require surgical intervention. One must also keep in mind that a slowly deepening coma or a continuing coma even without focal signs may mean a subdural hemorrhage.

From this point on let us consider the important effects of head trauma with any one or any combination of complications which may be found in a patient who is brought to the hospital in coma.

FRACTURE OF THE SKULL

Many valuable papers have been written on this subject that of Vance¹² (1927) being especially useful when consid

ering fatal cases that have been examined postmortem. One hundred cases followed from five to thirteen years have been reported by Earley.¹³ Sequelae in ninety one cases of depressed fracture of the skull have been reported by Glaser and Shafer¹⁴ in patients who were observed over a period of eight years.

A simple *classification* of skull fracture is given by Brody and Munro¹⁵ follows

- Linear and/or comminuted fracture
- Depressed fracture
- Compound fracture
- Special fractures (basilar) involving
 - Paranasal sinuses
 - Petrous bone
 - Cribiform plate (ethmoid)

The skull may be fractured without damage to the brain or without causing loss of consciousness. Some basal fractures are very difficult or impossible to detect by x-ray examination and the presumptive diagnosis rests on the history of adequate trauma followed at once or soon thereafter by extravasation of blood into the conjunctiva, bleeding from the ear or the flow of cerebrospinal fluid from the ear or nose, facial paralysis of peripheral type or deafness (either nerve or middle ear type) or some other cranial nerve defect known not to have been present before the accident.

Some useful observations have been made by Glaser and Blaine¹⁶ on the *duration* of skull fractures as visualized by x-ray. These authors state that linear fractures in children under six disappear within six to twelve months after injury. The majority of linear fractures in adults show fading from eighteen to twenty four months after injury and entirely disappear within four to five years, rarely longer. Some however begin to fade six to nine months after injury and disappear twelve to eighteen months thereafter.

Fracture through the squamous portion of the temporal bone is often associated with severe *epidural hemorrhage* from a tear in the middle meningeal artery which is lodged in a groove on the inner surface of the bone. This type of hemorrhage needs special description and management. The classical history in such accidents is that the patient receives a blow to the head which renders him unconscious for a short

time. He picks himself up and is able to go home. Some few hours later he is found unconscious and may have a hemiplegia. He will remain unconscious and will die within a few days unless the nature of the lesion is understood and treated surgically. The lucid interval in these cases is due to the fact that the brain itself has suffered only concussion with no other damage until the arterial hemorrhage outside the dura becomes large enough to cause compression of the brain. However in severe head injuries we frequently find more than one type of pathologic damage within the skull.

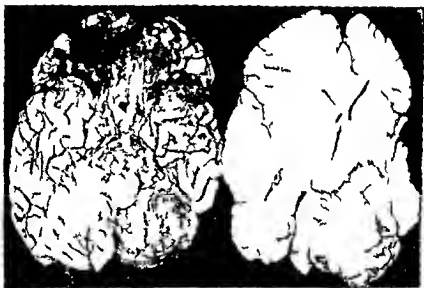


Fig. 85—Skull fracture and epidural hemorrhage complicated by laceration of the brain, subarachnoid hemorrhage and petechial hemorrhages of frontal lobe and corpus callosum (Belleue Hospital).

For example, such a patient may not recover consciousness after the extradural blood clot is removed by the surgeon because he has a laceration of the brain in addition (Fig. 85) or he may even have a bilateral epidural hematoma as in the case illustrated in Figure 86. In such complicated cases the patient may have no lucid interval after the accident but remains in coma. The only way to be sure of the diagnosis is to make a burr hole on the side we believe the lesion to be and if it is not found to make another on the opposite side. It is well to explore the dura with a small spoon as far be

yond the burr hole as possible so as not to miss the hemorrhage

Other complications of skull fracture are *meningitis* and *brain abscess*. We have even seen epidemic (meningococcic) meningitis result from fracture of the base of the skull. In depressed fracture where the fragments have been removed the cranial defect never becomes smaller—the only change is a rounding of the edges. These facts have considerable medicolegal importance.



FIG. 86.—Bilateral epidural hemorrhage (Case from Collection of Medical Examiner, Bellevue Hospital.)

Simple linear or comminuted fractures require no treatment per se. *Depressed fractures* should be operated on except in the case of children who have no evidence of direct injury to the brain underneath. Otherwise the depressed fragment should be elevated sometime during the first few days after the accident. In septic cases operation might have to be delayed but depressed fragments if left in situ often cause epilepsy later.

Many depressed fractures are also compound and require special surgical treatment. These should be operated on with

in five or six hours or as soon as shock has cleared up. If this is not possible then operation in two or three weeks after the scalp has healed is best. Verbrugghen¹⁷ King¹ Brody¹⁵ C. laser and Shafer¹⁴ Mocl and Mock¹⁰ Voris Verbrugghen and Kearns⁹ and others have given detailed instructions within recent years for the management of such injuries.

An unusual case of a fracture through the base of the skull was seen by the author in Cornell Clinic recently through the courtesy of Dr. Bronson Ray. This was in a woman of sixty one who fell down a short flight of stairs bumping her head as she fell. She did not lose consciousness and was able to get up and go to her bed two floors above. She was nauseated and vomited several times. Next morning she felt a throbbing pain in the right frontal region and an unusual noise in her head. Her right eye was closed, blind and bulging forward. During the next few days she had a headache and the noise persisted. A ray examination showed a fracture of the skull with an injury to the right optic nerve. Evidently also she had sustained an injury to the right carotid artery and the cavernous sinus with the establishment of an arteriovenous fistula between them giving rise to most of her symptoms including the headache and the noise in her head. This noise could be heard with the stethoscope as a bruit over the right side of the head.

Fat emboli may occur after a fracture of the skull as well as after fracture of the long bones of the skeleton (Vance). Osteomyelitis of the skull is a rare complication (King⁹).

SUBDURAL HEMORRHAGE OR HEMATOMA

Subdural hemorrhage or hematoma may be acute or chronic and is often found without fracture of the skull.¹⁻³ Like epidural hemorrhage this lesion is frequently complicated by others due also to the brain trauma. First it may be bilateral. It is frequently associated with lacerations of the brain which prove fatal in spite of early recognition of the subdural hematoma and its adequate surgical treatment. At times both epidural and subdural clots are found on the same side of a brain or in other cases with one or both lesions bilaterally.

Like epidural hemorrhage the condition may be suspected in an injured patient who does not recover consciousness after an accident or who after a more or less lucid interval be-

comes more drowsy and again sinks into coma. Especially is this true when there is no fracture of the skull through the temporal region. The diagnosis is often impossible without air studies or bilateral burr holes. Even in a patient with hemiplegia we cannot be sure which side the hemorrhage is on. In very many cases hemiplegia due to subdural hematoma is ipsilateral if the brain stem is pushed toward the opposite side where it may be cut into by the sharp edge of the tentorium.



FIG. 8.—Subdural hematoma complicated by incisure of the crus

num cerebelli. This damages the pyramidal tract which has yet to decussate lower down and causes hemiparesis on the side of the hematoma (Fig. 87).

At one time it was believed that when the pupils were unequal the hematoma would be found on the side of the larger pupil (Holman and Scott¹). This sign is no longer felt to be reliable. Diagnosis then must rest on the placing of *burr holes* on both sides of the skull—first on the side where neurological examination would lead one to expect the hemorrhage. It is almost necessary in any case to examine both sides for reasons noted above.

According to the technique of Laudig Browder and Watson the patient is placed face down on a cerebellar out-

triggers and the holes are placed slightly more distant from the midline and somewhat anterior to the conventional position used for ventricle puncture. The burr holes may reveal the lesion but if not air is introduced into the ventricles. Figure 88 shows the unusual anteroposterior ventriculographic picture found in subdural hematoma. The whole system is pushed away from the lesion with compression of the ven-



Fig. 88—Encapsulated mass of large encapsulated subdural hematoma of right side showing compression of anterior part of right ventricle, dilatation of left lateral ventricle and shift of ventricular system to the left (Woman, 37, Bellevue Hospital).

tricle on the side of the lesion and some enlargement of the opposite ventricle. Occasionally this picture may result from unilateral cerebral edema alone. In a plain x-ray of the skull one may note displacement of a calcified pineal gland which would enable the examiner to tell on which side the hemorrhage lies.

After hemorrhage has occurred in the subdural space it

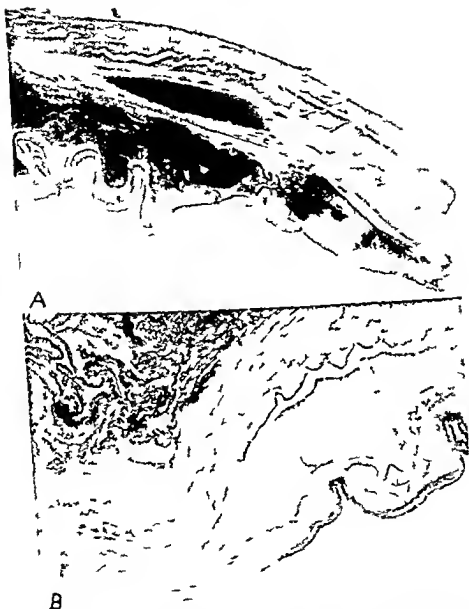


FIG 89—*A* Photomicrograph of a chronic subdural hematoma showing dura mater with vascularized thick membrane attached to its undersurface next the hematoma and nearest the brain, a thinner avascular fibrous membrane enveloping the hemorrhage. Note large hemorrhage in the vascularized membrane (Man of 70 Bellevue Hospital). *B* Photomicrograph in same case to show a secondary hematoma also completely encapsulated but attached to the inner membrane of the original hematoma.

sooner or later becomes encapsulated by a fibrous tissue envelope. Evidence of this process has been found by Browder and others as early as the fourth day after the accident. Fig

ure 89 *A* shows a chronic subdural hematoma well encapsulated. Immediately beneath the dura we find a thick, very vascular membrane, then the blood clot, and then (in contact with the arachnoid) a thin, vascular fibrous membrane. This inner membrane is often divided and hemorrhage is found in the space thus formed (Fig. 89 *B*). Sometimes (as seen in Figure 89 *A*) we find a considerable hemorrhage occurring within the vascular membrane next the dura. This may well add to the size of such a lesion and further increase the intracranial pressure. Osmosis has been suggested by Gardner to cause gradual increase in size of the mass inside the fibrous sac or envelope.

The clinical picture of chronic subdural hematoma is well illustrated by one of our cases as follows:

W. H., age fourteen years, came for examination in November, 1940. He complained of severe headache and vomiting. Examination revealed a bilateral choked disk. The rest of the neurologic findings were normal. A diagnosis of expanding lesion of the brain was made without localizing signs. We felt he might have a brain tumor. He said nothing about a trauma, and only later did we find out that in the previous August he had been hit on the jaw while boxing. He was not rendered unconscious and he forgot about the incident. Following air studies in January, 1941, he was operated on and a subdural hematoma was removed. He made a complete recovery.

This case illustrates some important points. First, the trauma may be without fracture of the skull and without unconsciousness. It is often not related in the history unless care is taken to make specific inquiry about it. Next, it is often impossible to localize the lesion by neurologic examination alone, even with a normally conscious patient. Further, the case shows that by whatever mechanism it is brought about, such a lesion may gradually cause increasing intracranial pressure over a period of many months. Laudig and co-workers relate the case of one such patient who had been injured two and one half years before operation.

SUBDURAL HYDROMA

There are a few less common effects of head trauma which should be noted. Occasionally, for example, fluid instead of

blood will be found in the subdural space (subdural hydrops) This fluid may be slightly blood tinged and may become encapsulated like a chronic subdural hematoma (Laudig Browder and Watson) Presumably this fluid escapes from the subarachnoid space through a tear in the arachnoid occasioned by the trauma With proper surgical intervention the prognosis is good

AEROCELE

Air may enter the cranial cavity in cases of compound fracture of the base of the skull which opens into the nose or one of the accessory nasal sinuses This condition is discovered when an x ray is made of the skull and the air is seen in the subdural or subarachnoid spaces and occasionally also in the ventricles This condition is called aérocele and in itself needs no special treatment Of course it may be followed by an infection of the leptomeninges or it may be associated with the dripping of cerebrospinal fluid from the nose

DELAYED TRAUMATIC INTRACEREBRAL HEMORRHAGE

There is a condition described as delayed traumatic intracerebral hemorrhage which is of medicolegal importance It has recently been reviewed by De Jong ⁷ (1942) This author makes one statement with which we wholeheartedly agree namely To assure a conclusive diagnosis a pathologic examination or surgical evidence is necessary We emphasize this statement since it is difficult for us to see how a *mild* injury to the head might be followed by the development of foci of softening in the cerebrum or medulla alterations in the blood vessel walls and intracranial hemorrhage as was suggested by Bollinger in 1891 and again by De Jong in 1942 In severe trauma to the head one may find scattered petechial hemorrhages in the brain in some cases or larger hemorrhage in others One can understand also that damage may be done to blood vessel walls in severe head injury (de Veer and Browder⁸) and later it is possible perhaps that such damaged vessels might be a factor in a delayed apoplexy This would be easier to understand in individuals who had previous blood vessel disease in the brain such as arteriosclerosis intracranial aneurysms or other vascular anomalies

LACERATION OF THE BRAIN

Laceration of the brain is well illustrated by the case of a man who jumped from a hospital window several stories up and was dead by the time the house physician reached him. Figure 90 illustrates his brain with a complete severance of the corpus callosum which at the moment of landing had come in contact with the fall cerebri which has a sharp cutting edge. There is considerable hemorrhage about this laceration. One can see also in this brain contusion with slight



Fig 90 Laceration of brain (the corpus callosum is severed) after a fall from a height

laceration of the temporal lobes with some cerebral and subarachnoid hemorrhage where the brain came into violent contact with the base of the skull. Subarachnoid hemorrhage may of course be quite extensive in some injuries.

INJURIES OF THE SPINAL CORD

Immediate Management

In the management of spinal injuries with or without pathologic involvement of the spinal cord an important matter to keep in mind is the method of handling the injured

person immediately after his trauma. He should be carried face down either by two people or lifted onto a stretcher face down and kept in this position until seen by the surgeon. Details of the management of these cases can be found in special articles such as those by Coleman and Meredith⁹ and Wortis and Sharp.³⁰

When there is evidence of a complete or nearly complete transverse lesion of the cord a tidal drainage apparatus for the bladder should be installed as soon as possible. This apparatus has saved many patients from fatal bladder and kidney infections. It is desirable to keep the legs and trunk warm and this is best done by the use of several electric lights hung in a cradle since hot water bags in contact with the patient may easily burn the anesthetic skin.

FRACTURE DISLOCATION OF THE NECK

In the case of a severe trauma to the head especially when a bulky object has fallen from above one must keep in mind the possibility of a fracture dislocation of the neck.

The case of A. C. illustrates this condition. This man was hit on the back of the neck by a bale of straw weighing about 160 pounds that fell from an upper story. He was unconscious for three or four minutes and later felt severe pain in the lower part of the neck and in the left forearm. His hands felt numb. There was weakness in both hands, some sensory loss in the arms and a bilateral Babinski sign. There was no paralysis of the legs. He died eight days following injury.



Fig. 91—Hematomyelia associated with fracture of the cervical spine (sixth cervical) showing pencil of hemorrhage in central portion of spinal cord.

This man had a partial dislocation of the sixth cervical vertebra with a hemorrhage into the central portion of the spinal cord (hematomyelia, Figs. 91-92). This is the usual

result of a nonfatal fracture dislocation of the neck. It produces weakness or paralysis of the grip bilaterally with later wasting of the muscles in the hand, loss of pain and temperature sensation over the hand and arm while touch is usually entirely well preserved. There is often some return of function in the hand and arm muscles but with some residual atrophy and weakness.



Fig 9 -M iopl otogr ph s the ca e

A less severe condition in the spinal cord following after many months of a partial dislocation of the cervical spine is illustrated by the following case

Mrs P age seventy eight years was in an automobile accident in 1905 and in a taxicab accident in 1930 when her head went through the window of the taxi. She consulted me first two years after the latter accident because of heaviness in her feet and pain in the soles of her feet which at times also felt as if they were asleep. This had been present for one year when I first saw her. The condition progressed slowly until March 1940 when I saw her again. At this time she had great difficulty in walking she had an ataxic gait and had no reflexes at the knee or ankle there was impairment of position and vibration sense in the legs.

Figure 93 shows an x ray picture of this patient's cervical spine. Evidently she had sustained a fracture dislocation of the neck probably in her second accident. She had no great discomfort at first but through long continued displacement of the vertebrae in the neck there had been traction on her spinal cord which gradually caused degeneration of the long pathways in the spinal cord resulting in a clinical picture



Fig 93—Old injury to the cervical spine (C_4 and C_5) followed years later by degeneration in long pathways of the spinal cord

resembling that seen in subacute combined degeneration of the spinal cord. There was evidently no hematomyelia in this case.

MYELOMALACIA

Another case of injury to the spinal cord is of great interest

E. M., a woman of fifty, was admitted to Bellevue Hospital in July 1938 with a history of having fallen from a subway platform to the tracks striking the back of her head, neck and trunk. She did not lose consciousness but immediately noticed that she could not move her legs or her body and later found it difficult to move her hands. She died three and one half months after her injury.

There had been neither dislocation of the spine nor fracture in this case. At autopsy the spinal canal seemed intact in every way but there was softening of the cervical cord although there was no evidence of hemorrhage in or about the cord. Figure 94 shows a cross section of the cervical cord. The lesion here (myelomalacia) was probably caused by contusion. In less severe trauma to the back a person may

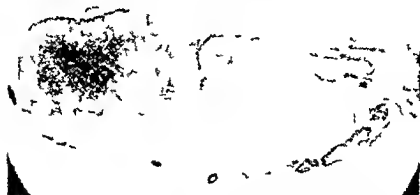


Fig. 94—Cross section of cervical region of spinal cord showing myelomalacia due to contusion (Pellevue Hospital)

receive a simple concussion of the spinal cord with diminished deep reflexes and inability to void urine. After a few hours these symptoms disappear without any residual disability.

RUPTURED INTERVERTEBRAL DISKS

Herniation of the nucleus pulposus of the intervertebral disk, especially between the fourth and fifth lumbar vertebrae, is one of the commonest causes of the sciatic syndrome. The usual history is that the patient while lifting a heavy object feels a sudden pain in the lower back. Later pain is also felt radiating down the back of one leg. The pain persists and neurological examination will often reveal a diminished ankle jerk on the affected side and perhaps some loss of sensation about the outer malleolus when compared with the sensation on the inner aspect of the ankle. The pain is aggravated by coughing or sneezing.

Lumbar puncture in such cases may reveal an increase of total protein in the spinal fluid. The increase is usually slight

and sometimes the protein is normal X ray examination of the spine is usually negative Occasionally 2 cc of lipiodol may be introduced into the spinal subarachnoid space and allowed to descend to the lower end of the canal and cauda equina where it may be demonstrated by x ray A filling defect can sometimes be seen where the disk protrudes into the spinal canal

Herniated disks may occur in the cervical region and also in other parts of the spinal cord causing pressure on the anterior horns of the spinal cord When the lesion is in the lower cervical region there is usually some atrophy in the muscles of the hand This important subject is discussed by several authors³ who have had much experience with the condition Dandy³³ and Smith³⁴ have recently attempted to simplify the diagnosis of this lesion and have outlined its treatment

SPINAL INJURIES DURING SHOCK THERAPY AND BY CHIROPRACTIC MANIPULATION

The recent descriptions of injuries of the spine occurring during the convulsions produced by metrazol insulin or electro fit therapy of the psychoses seldom include any mention of cord injuries (Hansa and Bennett³)

An important group of traumatic injuries to the spine with serious and sometimes fatal outcome is that produced by chiropractors (Blaine³⁶)

EPILEPSY RESULTING FROM CEREBRAL TRAUMA

At times epilepsy is a sequel of brain injury If the dura has been torn and the underlying brain cortex injured the dura may adhere to the injured brain At this point as has been shown by Foerster and Penfield³ (1929) a scar forms which is composed of fibrous tissue neuroglia and blood vessels for the most part During the ensuing months and years this scar contracts and pulls the ventricular system towards the side of the lesion There is usually some loss of brain substance with an increase in size of the lateral ventricle on the side of the lesion In such cases (which however are usually due to gunshot wounds of the brain or to cerebral trauma at the time of birth) focal or generalized epilepsy may result

The time between the wound and the onset of convulsions in Foerster and Penfield's series varied between five months and fourteen years. The injury to the dura of course was the essential feature in that series of cases.

Epilepsy resulting from cerebral trauma is comparatively rare. Aldren Turner³ reports that out of 18 000 cases of gunshot wounds of the head reported to the Ministry of Pensions (in Great Britain) less than 5 per cent have developed epilepsy. The figures on this subject vary greatly however as reported from different clinics from 2 or 3 per cent up to 25 or 30 per cent. These cases are also divided into (1) immediate epilepsy in which epilepsy occurs twelve to twenty-four hours after the injury, (2) delayed epilepsy with the onset in the convalescent period that is two to four weeks after injury and (3) late epilepsy when the symptom appears after a few months or a year or two following cerebral injury.

In one of my own cases it followed about nine months after an injury with fracture of the skull. The fits were precipitated by drinking alcohol. Over a period of five years now during which time the patient has taken no alcohol and only a small amount of phenobarbital ($\frac{1}{2}$ grain every night) he has had no fits.

In such cases air studies should be made in an attempt to localize the lesion and if this does not demonstrate its site electroencephalography may be useful. Cortical lesions whether or not of traumatic origin can often be accurately localized by this newer method (Jasper et al.³⁰). Subsequently the lesion should be dealt with surgically according to the method outlined by Penfield⁴⁰ and others.

POST TRAUMATIC NARCOLEPSY

Post traumatic narcolepsy has been reported by Hall and Le Roy⁴¹ (1936) as well as by others. However as with epilepsy this condition may antedate the accident and have no relation to it. Both epilepsy and narcolepsy are very rare sequelae of head injury and since epilepsy at least is one of the commonest conditions seen in any neurologic clinic great care must be exercised in establishing the fact that such conditions are due to cerebral trauma.

POSTCONCUSSION SYNDROME

In our opinion one of the most difficult problems to deal with is the so called postconcussion syndrome. Any individual who has had a serious trauma to his nervous system and complains thereafter of persistent symptoms such as head ache, dizziness or other distressing conditions is worthy of our best efforts to cure him and when indicated to compensate him. However there is an increasing horde of people who having been injured very slightly or not at all are receiving treatment and compensation at the expense of the community simply because of their complaints. It is safe to say that in general those individuals who complain most loudly have least wrong with them. When a man has an obvious injury he does not need to complain. Most physicians and others interested are anxious to see that he is adequately and justly dealt with. It is now well known that the soldiers who were removed from the front line trenches in the last war because of shell shock seldom had wounds (Kennedy⁴). Shell shock is hysteria and is a mechanism for solving an immediately dangerous problem. It was useful to the soldier biologically because it saved his life. Dr. Foster Kennedy and others have demonstrated the psychological mechanism underlying shell shock.

It is recognized of course that a man may have a serious organic injury to some part of his body from which he suffers some permanent disability and yet maintain that he has in addition a paralysis of one leg or some other defect which is easily shown to be hysterical in origin. The real disability may not be regarded as total whereas the real one plus the added hysteria may cause it to be so regarded.

First of all let us consider cerebral concussion. As far as we know there is no permanent damage to the brain or spinal cord in cases of simple concussion. It is a condition from which the person completely recovers in a matter of minutes or hours. It is well illustrated in the prize ring when a boxer is knocked out for ten seconds or more. He recovers gradually and is quite normal within a short time unless along with the concussion he has suffered a more serious brain lesion such as one of those already described. Or unless he has received

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we have seen the diplopia was the result of direct injury to one of the extra ocular muscles from hemorrhage resulting from a blow near the orbit

FUNCTIONAL NERVOUS DISTURBANCES FOLLOWING TRAUMA

In a consideration of the functional nervous disturbances following an accident one must first of all determine that the individual was actually hurt and did indeed suffer a cerebral trauma as indicated by the criteria noted already in this article. Or in certain cases one might agree that the nature of the accident was so terrifying or frightening that it constituted a psychic trauma which had temporarily caused nervous disability. A workman for example, who had fallen several stories from a scaffold and had been severely injured might find it difficult or impossible to return to the kind of work which would again expose him to similar danger. His job might have to be changed before his nervousness would disappear.

In a surprisingly large number of compensation cases in which disability from a postconcussion neurosis is claimed the claimant has received no cerebral trauma whatever and no psychic trauma and his nervousness should not be attributed in any way to the accident. This subject is in such a state of chaos at present that the best way in the author's opinion to deal with it would be to allow no compensation whatever in such cases. Less injustice would be done than at present and few injured persons would be inadequately compensated. Many lawyers and some doctors would of course object but compensation neurosis would disappear and more funds would be made available for the management of men and women who *have* been injured. One case will illustrate my point.

A Greek cook was admitted to the Neurological Service of Bellevue Hospital (service of Dr Foster Kennedy) some time in 1920. He had an hysterical paralysis of his left arm. The history showed that he had overturned a pot of hot fat and had burned his left forearm. While it was being dressed (he stated) the surgeon suggested that the nerves in the arm had been damaged. The wound healed very well and there should have been no fur-

ther disability. However the surgeon's suggestion aided the man in the development of the hysterical weakness of the arm due to the supposed nerve injury. It was shown beyond any doubt that there was no nerve injury. The man had an hysterical anesthesia over most of the arm. An attempt was made to treat the neurosis by suggestion and other means and some success was obvious since the level of the anesthesia was soon lowered. The treatment was vigorously continued until one day almost all of the sensory loss had been restored. Then suddenly the man became angry and left the hospital against advice. We lost sight of him until several years later when I met him by accident on the street. He exhibited a typical hysterical paralysis of the whole left side of his body.

This case amongst other things illustrates the futility of attempting to treat such a neurosis. Even a lump sum settlement of such a case does not always cure it. There is a prevailing superstition in certain quarters that a post-traumatic neurosis is worth at least \$75,000. It is typical also that such a neurosis gets worse as time goes on. The suggestion which is responsible for the disability does not always come from the surgeon. It may emanate from friends or after meditation from the patient himself. Patients like this make a dramatic and successful appeal to the average compensation commissioner or jury.

That a person may be nervous or psychotic as the result of a cerebral trauma is of course conceded by all neurologists even when the neurological status is objectively normal or nearly so. In fact a single case from my recent experience will illustrate this.

A young woman while learning to fly crashed 50 feet with her glider and received serious injuries. She was immediately rendered unconscious and remained unconscious for three days. She had a fractured nose, a fracture of the base of the skull and a fracture of the humerus. She had signs of organic disturbance in her brain such as unequal pupils and a Babinski sign on one side. On recovering consciousness she was disoriented and incoherent in her speech. She became impulsive in her behavior and dangerous to the nurses. She was easily annoyed and seclusive. She lost all memory for events leading up to the accident. She improved gradually after several weeks in the hospital. The diagnosis was traumatic psychosis. This patient had had no previous

mental or nervous illness and she had no family history of mental disease

Dr Adolf Meyer⁴⁷ has classified the post traumatic psychoses and includes cases developing in senile or alcoholic subjects

MISCELLANEOUS EFFECTS OF TRAUMA

Paralysis Agitans—The relation of trauma to paralysis agitans is well discussed⁴⁸ elsewhere. It is pointed out that the relation of trauma to paralysis agitans still remains an open question.

Brain Tumor—The relation of trauma to brain tumor is discussed by Parker and Kernohan.⁴⁹ Their paper deals particularly with glioma of the brain and is based on a controlled study of 431 cases of glioma. They conclude that glioma of the brain as a sequel of injury to the head must be exceedingly rare and comes within the possibility of coincidence.

Electrical Damage to Nervous System—The question of electrical shock to the nervous system is of considerable importance. Fetterman and Smiley⁵⁰ describe disturbed conduct in a boy of twelve following a severe electric shock (4000 volts) with burns to one hand, buttocks, shoulders and head. The boy survived the shock and consequently nothing is known of the condition of the brain lesion. This subject is well described by Alexander⁵¹ who covers the clinical picture, pathogenesis, pathology and treatment with a review of the literature up to 1938.

Birth Injuries—The question of birth injuries to the nervous system requires special description. This has been done well by Ford, Crothers and Putnam in a monograph.

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INJURIES OF THE EYES AND EYELIDS

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and

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THE human eye is a sensitive organ composed of a dense capsule of cornea and sclera containing aqueous and vitreous humors and chiefly nervous, vascular and highly specialized tissues which react in peculiar manner to injury.¹⁻³ The eye is protected by the brows and eyelids from minor injuries but no artificial safeguards have yet been devised to protect it against bullets and metallic missiles from high explosive shells or from the danger of sympathetic ophthalmia. Various gases and chemicals especially are a hazard to the eyes particularly when the concentrated form is splashed about the face. Infections particularly with the tetanus bacillus are also an eye risk. The final effect of injury of the eye is not always apparent and a year or more may elapse before it is known for example detachment of the retina or cataract. Prognosis therefore should be guarded.

PREVENTION OF INJURY TO THE EYES AND EYELIDS

Soldiers and others in warfare who must wear glasses or goggles should have the nonshutterable types so that they will be free from the hazards of injury from pieces of their spectacle lenses. Workers in industry should be likewise pro-

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Illustrations loaned through courtesy of Dr. J. H. Dunnington, Instructor of Ophthalmology of Presbyterian Hospital in the City of New York. Artists: Mr. G. B. Thibault and M. Quinlan.

ected from flying particles and from various harmful radiations.⁴ Workmen should never use hammers which chip easily when used on metallic tools. Students and workers in laboratories should be told time and again never to look down into a test tube. Children playing with air rifles slingshots rubber band shooters cylinder shooters sticks and so on should be constantly reminded of the danger of irreparable damage to their own eyes and those of their playmates.

It is important to remember in injury of the eyelids the possibility and even probability that the eye itself has been injured. If the lids are closed through hemorrhage or edema or both adequate careful means of retracting the lids for exposure and examination of the eye must be adopted early so that proper treatment may be given to the all important eye itself.

The possibility of embedded foreign bodies must always be kept in mind and the x ray should be used as soon as possible for the determination of the presence and the accurate localization of any radiopaque foreign body. Some forms of glass do not cast shadows or the latter may not be of sufficient size or density to be discovered unless bone free x rays are employed. Certain particles may be discovered by means of the ophthalmoscope or by the aid of the contact glass and gonioscope when the glass is in the angle of the anterior chamber.

METHODS OF PROTECTION OF THE EYES OCULAR DRESSINGS

For the protection of the eye after operations or injuries sterile vaseline or a suitable commercial eye ointment is placed on the closed lid margins which are then covered with a piece of sterile gauze and over this a layer of sterile cotton or gauze. The dressing is held in place by strips of adhesive plaster or Scotch tape. If pressure is desired more cotton is heaped on and the whole held firmly in place by strips of adhesive plaster placed with pressure over the dressing. The strips should be placed diagonally across from the central brow area to the cheek adapting to the contour of the orbit. If a roller bandage is desired ointment is placed on the closed

lid margins then gauze and cotton are placed over the lids as described. The end of the roller bandage is placed on the forehead just above the eye to be bandaged and passed to the opposite side. The bandage is then given one snug turn straight around the head and in such a way that the highest point of the occipital prominence is in the center of the strip. The bandage is then carried on around inclining downward but always keeping well above the uncovered eye. It passes just above the eye on that side then across the base of the occiput and close up beneath the other ear then diagonally upward over the center of the pad of cotton and almost vertically across the forehead as if it were going over the top of the head. Now it is reversed carried downward and backward around again passed again over the pad of cotton this time with its edge against the nose—up and reversed as before carried a third time around and up. This the last turn that lies on the cotton pad is carried more toward the temple so that now the entire pad is covered. It is again taken upward and reversed but instead of passing downward at the back what remains of the bandage is passed straight around the head as was the first turn. The end is fixed with strips of adhesive plaster one of which may be placed with adhesive side up before the roller bandage is started. Reinforcement of the roller bandage with starch never with plaster is indicated in young children. Reinforcement with additional layers of bandage or better with 1 inch adhesive strips is desirable when it is necessary to leave the dressing on for some time as after plastic surgery on the eyelids.

If the cornea is exposed because of destruction or retraction of the lids it requires protection and moisture to prevent erosion and ulceration with ultimate perforation. A moist chamber may be devised with glass or plastic. White vaseline or a nonirritating eye ointment may be used inside of a cone shaped dressing. Freeing of tissues and suturing of lids together in temporary or permanent intermarginal lid adhesions may be necessary. Plastic surgery should be done for the protection of the globe. Every possible millimeter of lid margin and tissue and conjunctiva should be saved after injuries of the eyes because they are difficult if not impossible to replace. Metal and plastic shields fitted to the orbit single

and binocular masks shaped of reinforced cloth are very helpful in preventing injury to the eye by the careless or sleeping patient

NONPENETRATING INJURIES OF THE EYE

CONJUNCTIVAL AND CORNEAL LACERATIONS

Conjunctival lacerations may be closed easily by means of interrupted silk or plain catgut sutures under instillation an esthesia (such as pontocaine) The repair of lacerations of the cornea requires considerably more skill Instillation and subconjunctival anesthesia may be used The conjunctival sac is cleansed carefully with normal saline solution If a portion of the iris has prolapsed (Fig 95) it should be excised with

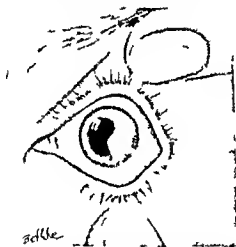


Fig 95—Laceration of the cornea with incarceration of the iris (Courtesy Dr R Pfeiffer)

the aid of iris forceps and scissors The protruding iris is grasped and drawn forward with the forceps and cut off having the blades of the scissors flat with the cornea and as close to it as possible If there is a difference in the level of the edges of the wound of the cornea the edges should be sutured with fine black silk corneal sutures to insure proper apposition Coaptation may be encouraged by cutting the conjunctiva near the limbus in the hemisphere involved and undermining well back Sutures are placed at the limbus one on each side opposite the flap then through the undermined edge and tied bringing the apron like flap over the wound

REMOVAL OF FOREIGN BODIES

When a foreign body is located on the *tarsal conjunctiva* the upper lid is everted with the end of a cotton applicator while the patient is looking downward with both eyes open thus relaxing the muscles. If the foreign body is located on the *cornea* (Fig. 96) it is removed with a minimum of trauma to the cornea. A good light preferably with parallel beam is essential. A binocular magnifying loupe is helpful. The eye is anesthetized with pontocaine. Cocaine is to be avoided.

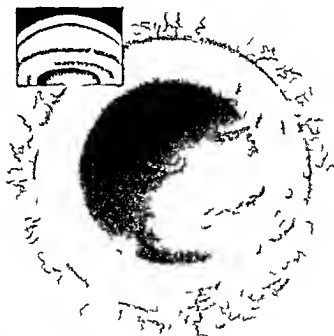


Fig. 96—Foreign body near left eye of 15-year-old girl (Cortez).
 (Photograph by Dr. G. Bruce)

A careful attempt is first made to brush off the foreign body with a cotton applicator moistened with saline or boric acid solution. If this fails the particle must be removed with a sterile pointed instrument placed under the foreign body so that it may be lifted off after which the eye is covered with a sterile dressing redressed daily and kept covered until the wound is well healed. The wound may be carefully treated with alcohol or 3 per cent solution of iodine on a tightly

wound cotton applicator *Care must be exercised not to penetrate the cornea*

If a particle of iron has been embedded for some time a ring of rust stain of the corneal tissues may remain after removal of the foreign body. The ring should be curetted or scraped away with a suitable instrument. In military and other explosive injuries multiple fine foreign bodies may pepper the cornea, conjunctiva and lid. The foreign bodies may be gradually exfoliated if the eye is not destroyed; those which remain may be removed carefully with instruments.

WOUNDS OF THE CORNEA

Superficial Wounds of the Cornea

Minor abrasions of the conjunctiva or of the corneal epithelium usually heal gracefully but if a foreign body is permitted to remain embedded in the cornea or on the under surface of the upper lid serious ulceration of the cornea may occur leading to opacity and diminution of vision. A *protective dressing* is essential. Any undue reaction may indicate infection. Inflammation of the iris requires the treatment advised for iritis. Local antiseptics are apt to be irritating and in the concentrations in which they are employed are generally not very useful in destroying bacteria.

Those who work with emery wheels, polishing and other machines which scatter dust and foreign bodies should be protected by adequate nonshatterable goggles.

TRANSPLANTATION OF THE CORNEA—For the relief of corneal opacity of varying density the operation of transplantation has been devised. Autogenous grafting of peripheral clear cornea to the central area is possible but unsatisfactory. Homogenous grafts from suitable donors such as from eyes enucleated for various reasons from the eyes of stillborn babes and from those of certain fresh cadavers have been found suitable for replacement of opaque material removed from the patient's cornea. Elschnig, Fildes, Hughes and Cistrowiejo have done excellent work in this field.

Recurrent Erosion of the Surface of the Cornea

Repeated attacks of erosion of the epithelium of the cornea may occur after relatively minor injuries of the epithelium.

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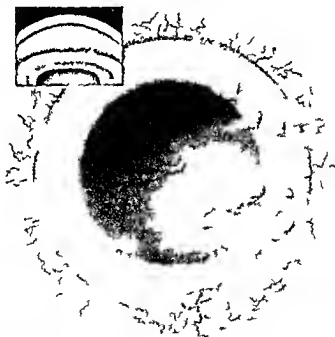


Fig 96—Foreign body on cornea of left eye. Inset: Gross photograph of foreign body. (Courtesy of Dr. G. B. Kirby)

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particularly if there is a virus invasion of the epithelium or if a deposit of foreign or other material is present on the surface of Bowman's membrane to interfere with proper apposition of the corneal epithelium to Bowman's membrane. Dendritic filamentous vesicular or other forms of keratitis may be seen. Usually curettement of the disturbed or diseased epithelium combined with removal of the deposit and polishing of Bowman's membrane and followed by the careful application of half strength tincture of iodine on a tightly wound cotton applicator is necessary. The cornea must then be protected by closed lids and a firm dressing for about ten days to allow the epithelium to cover the defect.

Chemical and Irradiation Trauma

Chemicals and excess visible and invisible irradiation may cause superficial and deep injuries. Acids, alkalis and salts burn and destroy the surface tissues. Permanent opacity usually results. Particular caution is urged in regard to *domestic lye, building lime, refrigeration gases and fluids, dyes, battery acid, solvents, paint and varnish removers, and military gases and chemicals*. Those who work with *methyl alcohol* should wear a proper mask to guard against its effect on the optic nerve. There should be a special warning on the container regarding the danger to the eyes.

WAR CHEMICAL INJURIES OF THE EYES

Beall⁶ has stated well the difficulties inherent in chemical and gas injuries of the eyes. The most serious chemical burns seen during military combat are caused by the vesicant gases, for example, mustard gas and ethyldichloroarsine. In 75 per cent of all casualties caused by mustard gas, mild or severe corneal burns are present. Treatment includes (1) reassurance of the patient that he is not blind, (2) refraining from the use of bandages, (3) irrigation with a mild hypertonic isotonic and neutralizing solution, (4) use of dark glasses and (5) convalescent care. Foreign bodies contaminated with such irritant gases may prove very destructive if they enter the eye or are embedded in the cornea.

Patients with complications, especially secondary infection, should receive treatment consisting of local instillation of 5 ro

10 per cent of sulfathiazole (2[para aminobenzenesulfonamido] thiazole) ointment and oral administration of 0.1 gm of sulfathiazole per kilogram of body weight every twenty four hours

Ocular burns caused by the lacrimating gases the lung irritants and the irritant smokes are treated symptomatically since they do not cause damage to the eyes that fresh air and a simple eye wash will not relieve. However if the liquid form is splashed into the eye the burn is treated as an acid burn unless it was definitely caused by an alkali such as ammonia

Mustard gas lewisite ethyldichloroarsine chlorine chloro picrin dipphosgene and sulfur trioxide *in vapor form* cause irritation of the eyes with watering blepharospasm smarting burning and other disturbing sensations. The eyes should be washed with a solution of bicarbonate of soda (1 teaspoonful to 1 pint of water). Bromobenzyl cyanide and chloracetophenone act similarly but for alleviating the symptoms boric acid solution (1 teaspoonful to 1 pint of water) is recommended. Oil must not be put in the eyes as this may hold some of the gas for further irritation of the eyes. In the prevention of effects of gas upon the eyes the civilian population should be warned in the event of a gas attack to enter a building or their homes go to the second or third floor and shut doors and windows. All harmful gases are heavy and will sink to the lower levels *

In liquid form any of the above gases may cause severe burns of the cornea and conjunctiva and require the immediate and prolonged services of an ophthalmologist in caring for the chemical burn which may cause erosion, ulceration or possibly perforation of the globe. Contact with incendiary bombs or with white phosphorus produces destructive burns of the eyes and eyelids

RADIATION INJURIES OF THE EYE

All who are exposed to heavy concentrations of ultraviolet rays for example motion picture actors being photographed under arc lights and sun bathers should be warned of the

Some of this information is taken from the data given out by Lieut Col W. P. Burn of the Chemical Warfare Service by special permission of Army Ordnance

danger of *keratoconjunctivitis*. Sun gazers particularly those who watch eclipses should know that a concentrated source of visible and invisible radiation may permanently destroy the central vision by the condition of solar retinal burn. Those who go on scientific expeditions to view eclipses should be properly protected by filters. Ordinary indirect exposure of the eye to the sun in the temperate zones will not harm the eye but the use of protective tinted *filter glasses* which are ground plane lenses will contribute to the comfort of the individual. The ordinary pressed forms of sun glasses which are sold widely are usually defective and have astigmatic and other aberrations which detract greatly from the benefit. Furnace workers and those exposed to high temperatures in concentrated areas should know of the effect of infra red rays in the production of *cataract*. The use of x ray and radium on the eye or eyelid may produce cataract. Lightning and high voltage electric current also may produce cataract as a late end result if the victim survives the shock. Those who do arc welding or who look into furnaces or engage in similar occupations should have protection by proper goggles.

The eye is particularly protected from excessive *cold*. While the eyelid skin may be affected by freezing temperatures the eye itself usually survives.

KERATITIS E. LAGOPHTHALMOS KERATITIS NEURO PARALYTICA

If the seventh cranial nerve is injured exposing the eye because of the loss of the protective lid muscles or if the fifth cranial nerve or the sympathetic nerves are destroyed thus removing the trophic and protective sensory and pain functions or if there is subvitaminosis or avitaminosis interfering with the nutrition of the eye coincident or subsequent trauma may be more devastating in its effect.

INDIRECT DIRECT AND CONTUSIVE TRAUMAS

Indirect Trauma to the Eye

Indirect trauma such as bodily or head shock may affect the delicate structures of the eye. In an elderly person with fragile zonular fibers the lens may be subluxated or dislocated and separation of the retina may occur particularly in eyes

which are myopic or in which cystic degeneration of the retina is present. The role of the trauma should be seriously considered but many cases of separation of the retina are observed in which there is no history of trauma.

Direct Trauma

In the instance of direct trauma however such as a contusing wound there may be no doubt of the relationship between the injury and the effects even though inflammation has supervened to increase the damage. The estimation of the effects of a relatively minor injury as when interstitial keratitis and uveitis are produced or precipitated in a luetic subject requires the services of an expert. If separation of the retina follows direct trauma characterized by the development shortly after the injury of opacity of the retina and visible tears no question remains as to the relationship to trauma.

Trauma by Contusion

Blunt objects striking the eye may produce the effects of contusion. These vary from commotion to rupture of the globe. Hypotony tears in Descemet's membrane and endothelium rupture or dialysis of the iris cyclitis commotion retinal detachment of the choroid retina and vitreous hole in the macula rupture of the choroid or retina avulsion of the optic nerve extra ocular and intra ocular hemorrhage and finally cataract may result. *Blood stain of the cornea* may persist long after injury of the endothelium of the cornea if there is also hemorrhage into the anterior chamber.

One of the typical effects of contusion is *hypotony*. The cornea may be wrinkled the aqueous contains more protein than normal there is a varying degree of inflammatory reaction and a complicated cataract may develop. Another effect of trauma is that of temporary or permanent *paralysis of the sphincter iridis* with dilatation of the pupil rupture of the iris or iridodialysis with hemorrhage in the anterior chamber. The effect of transmission of the contusing pressure contrecoup may be a *rupture of the globe* usually at its weakest portion, the intercalary area of the sclera. Extrusion of the contents of the globe the aqueous lens (Fig 97) and vitreous

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may occur beneath the unbroken conjunctiva. Lesser pressure transmitted through the fluid medium of the globe may produce a typical *curvilinear tear* usually part of a circle in the delicate choroidal vascular membrane (Fig 98) and seldom if ever involving the macula. The latter however is affected by such trauma in other cases there being produced a hemorrhage from the central area of the choroid and other tissue changes which result in a *hole* or cystic degeneration of the macula.

Detachment of the choroid may be produced by serous effusion in the suprachoroidal area while *separation of the*

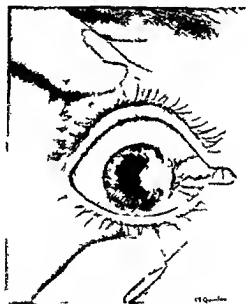


Fig 97—Bursting wound of right globe with aniridia and pupil on file
(Courtesy of Dr. D. T. Niles)

retina may be due to the same cause by effusion from the inner surface of the choroid. Usually a tear or hole in the retina has been developed which allows the altered vitreous to gain access to the subretinal space and further separate the retina. Ballottement of the fluid within the eye and the attachment of the vitreous to the ciliary body and the periphery of the retina may cause sufficient traction upon the retina to produce a dialysis or tear. Hemorrhage into the vitreous produces *opacity* and the final result may be *scar*

tissue bands, particularly if associated with an inflammatory reaction which in their contraction will pull off the retina. The prognosis for reattachment in such a case is very poor.

Degeneration of the posterior segment of the eye occurs from severe posterior contusions. Subconjunctival rupture of the globe may be a potential source of sympathetic ophthalmia. If the injured eye is soft and sightless it is well to enucleate the eyeball taking no chances on sympathetic

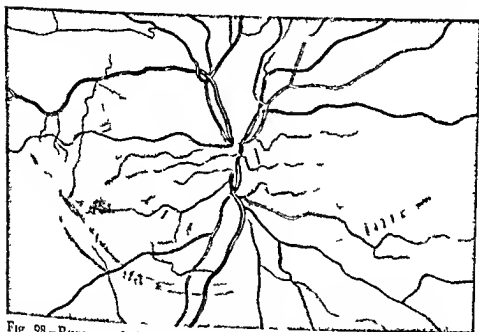


Fig 98—Rupture of the choroid of right eye following severe contusion

ophthalmia. In the same class as contused wounds may be considered the effects of either spontaneous or instrumental pressure on or bruising of the eye during childbirth.

PENETRATING INJURIES OF THE EYE

LACERATING PENETRATING OR PERFORATING TRAUMA

Eyelashes and bits of epithelium of conjunctiva or cornea may occasionally be detached by the injuring force and carried into the anterior chamber and if there are viable epithelial cells included the latter may grow and cause cyst formation or line the anterior chamber with squamous epithelium obscuring the vision by opacification obstructing the drainage angle and causing secondary glaucoma. Localized cysts may

be treated by withdrawal of the contents and injection and reinjection of half strength tincture of iodine diluted with the cyst contents finally withdrawing and collapsing the cyst. The only effective treatment for widespread *epithelialization* of the anterior chamber has been radiation.

In lacerations of the cornea through its substance but without perforation the lips of the wound will usually gape and will require reduction of the normal tension of the eye by paracentesis to allow apposition of the edges of the wound for healing. A penetrating wound of the cornea with loss of aqueous will usually do best if apposition of the edges is encouraged by a conjunctival flap brought over the wound. If there has been prolapse of the iris attempts at replacement of the iris are usually ill advised. Iridectomy had best be done unless the surgical findings contraindicate it.

Prophylaxis Against Infection

Deeper trauma should receive prophylactic treatment against tetanus infection and in some cases against gas bacillus infection. Sulfanilamide and similar drugs may be useful. Most of the bacterial and virus diseases of the eye respond to their use in sufficient dosage in the early and active stages. Careful nonspecific protein therapy after first determining the sensitivities of the patient may also be useful.

TETANUS TOXOID—Tetanus toxoid develops active immunity and in general it is a persisting immunity. The dosage consists of two injections of 0.5 cc. of alum precipitated tetanus toxoid given eight weeks apart as basic immunization in addition of 1 cc. at the time of injury if deemed necessary to raise blood antitoxin rapidly. Injection of 0.5 cc. each four years after basic immunization to maintain immunity at a high level.

The minimum antitoxin level necessary for protection against tetanus has not been measured. But the authors have shown that individuals with a serum antitoxin level of only 0.01 unit per cubic centimeter of serum respond rapidly with high blood antitoxin levels upon toxoid stimulation.

GAS GANGRENE ANTITOXIN—Although gas bacillus infection of the eye and orbit is rare the possibility of its development should not be forgotten. Prophylactic administration of

gas gangrene antitoxin⁵ is advised (1) where there is severe shock and operative treatment must be postponed for many hours (2) where there is extensive muscle injury especially if the wounds are contaminated with soil dust or rubble, (3) where fragments of clothing metal, and so forth have been carried deep into the tissues Give as soon as possible after wounding the following *doses* 3000 I U Clostridium welchii antitoxin 1500 I U Clostridium septicum antitoxin 1000 I U Clostridium oedematiens antitoxin

A combination of early antitoxin early surgical excision with local sulfonamide chemotherapy followed by oral sulfonamide chemotherapy holds out the best promise for preventing the disease

PENETRATING FOREIGN PARTICLES

Flying foreign particles are especially dangerous Fragments of radiopaque material may be located accurately by x ray and if of ferrous magnetic property may be removed with the magnet

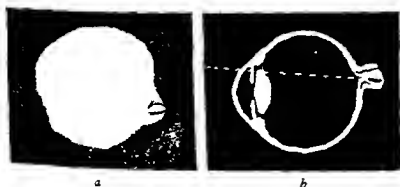


FIG 99—Foreign body (steel) in optic nerve left eye a X ray of enucleated eye b Schematic path of foreign body (Courtesy Drs J Dunnington and H McKeown)

FRAGMENTS OF GLASS—Minute fragments of glass may penetrate the cornea and then fall in the aqueous of the anterior chamber to the lower angle Alkali free glass may cause no chemical change but will act as an irritating foreign body Every eye injured with glass fragments should be examined with the gonioscope The x ray may disclose such material in the anterior segment if bone free exposures are used If discovered they may be removed through a keratome incision

Implantation of Sphere in Orb † Following Enucleation

In order to replace the bulk of the globe and to give better motility to the stump a glass gold or other nonirritating sphere—not less than 14 mm nor more than 18 mm in diameter in the adult—is inserted into Tenon's capsule. For suturing double armed No 0000 chromic ten day catgut is used in double mattress form diagonally across the opening in Tenon's capsule (i.e. between the rectus muscles forming a double overlap in the center). The conjunctiva is then sutured separately with plain No 0000 gut or with No 000000 black silk using four or five interrupted sutures. A firm dressing is applied with gauze and adhesive covered by a roller bandage quite firmly applied. This dressing is allowed to remain in place for four days being then replaced by a lighter pad. The socket should be ready to receive the prosthesis in ten to fourteen days.

The injury of the eye and adnexa may be so severe that the lids and contiguous skin, the globe and orbital contents must be sacrificed. Debridement should not be carried out unless parts are necrotic tissues which have a chance to survive should be conserved.

INJURIES TO THE LENS—TRAUMATIC CATARACT

Any injury to the lens capsule will result in opacity of the lens. Normally protected from the aqueous by the semipermeable membrane of the lens capsule the hygroscopic lens protein exists in a unique transparent colloid condition its integrity conserved by a process of selective osmosis. If the aqueous is brought into direct contact with the lens protein the latter imbibes water swells and becomes opaque. Injury to the posterior capsule allows the fluid of the vitreous to produce cataract but the opacity may not extend far. In fact it may remain as a partial stationary opacity.

Types of Injuries to the Lens—Injuries to the capsule are usually direct and accidental. However they may be produced purposely by the point or blade of the dissection needle in cases of soft cataract in young people to cause absorption of the opacity and lens material. Contusions of the eye usually

The material on traumatic cataract adapted from the article by
 of the authors (D.B.K.) in *British The Eye* and *Its Disorders* W.B.
 Saunders Co. 1936 Chap 37 pp 565-598

are followed by lens opacities. The method of artificial maturation or production of traumatic cataract by stroking the lens capsule with the iris spatula at the time of the iridectomy is *not* to be recommended.

Treatment of Traumatic Cataract

It is important at the outset to release any capsular tags which are incarcerated in the corneal wound which is then treated in a manner to promote prompt closing with restoration of the anterior chamber.

In *children*, the lens is soft and anterior chamber wounds often cause complete absorption although the procedure of rewounding the capsule may be necessary. In *young adults* if the lens swells rapidly it may be necessary and advisable to make a linear incision and wash out the broken down lens substance. If linear extraction is contemplated it is wise not to wound unnecessarily the posterior capsule or hyaloid of the vitreous retaining these structures as protection against loss of vitreous during the linear extraction. In *older persons* traumatic cataract presents a real problem owing to the hard nucleus which is present and which will not wash out through a small incision requiring a large opening for its expression. Early action to prevent iridocyclitis and a glaucomatous process advisable. Mydriatics are indicated even in uncomplicated cases to prevent synechia and to relieve congestion of the iris and ciliary body. The glaucoma is best treated by removal of the lens remnants.

Cortical material retained after the capsulotomy method of cataract extraction may be regarded and treated as a form of traumatic cataract. Certain individuals are sensitive to the action of their own lens proteins so that the presence of such free extracapsular material either in traumatic cataract or after extraction may produce iritis, cyclitis or endophthalmitis of varying degrees.

TECHNIC OF LINEAR EXTRACTION OF TRAUMATIC CATARACT

—Local or general anesthesia may be used. The pupil should be dilated with atropine or with a satisfactory substitute mydriatic and cycloplegic. The eyeball is fixed with forceps and a sharp keratome is used to incise the cornea about 2 mm from the upper margin. The opening should be about 6 mm wide permitting the aqueous to escape. The capsule of the

lens is removed with toothed or smooth forceps. Much of the broken down lens cortex may escape spontaneously. That which remains is washed away gently with the irrigator syringe (such as the Parker Heath) or is stirred up from within or outside the cornea with a spatula care being taken to prevent injury to the posterior lens capsule and possible loss of vitreous. If the injury involves both the anterior and posterior lens capsule then particular care must be used in handling the situation. All the lens material need not be washed out for the eye has a way of gracefully handling by means of lytic ferments that which remains. If membranes of capsule and fibrosed tissue remain after healing further dissection or removal of the membrane may be necessary in order to clear the pupil.

Foreign Bodies in the Lens

Small foreign bodies lodged in the lens if nonirritating may cause only slight opacity. A piece of copper in the lens however may lead to a complicated degenerated condition of the entire eye. A small piece of iron or steel may cause siderosis of the entire eye.

Contusion Cataract

Contusion cataract may develop weeks or months after a blow on the eye. Injuries by blunt objects are often followed by hypotonia and disturbed nutrition of the eye complicated by cataract difficult to remove. The ring shaped opacity described by Vossius is due to the presence of pigment and blood from the forced impact of the iris on the lens. It does not interfere with vision as it is outside the ordinary pupillary diameter and may partially disappear.

SYMPATHETIC OPHTHALMIA

DEFINITION—Sympathetic ophthalmia is a true inflammation in the fellow eye following upon related to and dependent upon intense plastic inflammation of an injured eye. The pathology is that of mononuclear cellular infiltration of the uvea with later plasma and giant cell formation but never with caseation or necrosis. It may look like tuberculosis of the eye but only a few have considered it to be due to the tubercle bacillus. Some consider it to be of unknown origin.

while still another theory offers pigment tissue allergy as important in its development. It has been known to develop in certain cases of neoplasm. It should be distinguished from sympathetic irritation and from uveitis of the fellow eye arising coincidentally but not due to the effect of the injured eye. The time of development is usually within two to eight weeks after injury, although two years may elapse. A soft irritable functionless eye which flares up in inflammation after injury had better be removed. If a wounded eye has healed promptly and has not shown any inflammation there is practically no danger. Purulent inflammation has not been known to lead to sympathetic ophthalmia.

RECOGNITION—The signs of inflammation plastic in nature in the injured eye, with disturbances of accommodation, photophobia, lacrimation and slight pain, and with the fellow eye exhibiting gradual loss of vision accompanied by signs of plastic uveitis, deep congestion, haziness of the cornea, cellular and fibrous deposits on the endothelium of the cornea, increased protein content of the aqueous with cells floating in the aqueous, congestion and irregular infiltration of the iris, vitreous opacity, choroiditis and alterations of intra ocular tension, are important in the recognition of sympathetic ophthalmia. The great misfortune is that when such a condition is recognizable the inflammation of the fellow eye is present and measures designed to reduce the inflammation and cure the eye are not very effective. Even enucleation of the injured eye at this stage is not effective and if the vision of the injured eye is better than that of the sympathizing eye it may be better judgment not to remove the injured eye as this in the end may prove to be the better of the two.

TREATMENT—Prompt *prophylactic enucleation* in cases of severe injury where there is no prospect of visual function is the best preventive treatment. *Foreign protein therapy* after testing for particular sensitivities and *sodium salicylate* in large doses of 1 grain per pound of body weight daily are recommended. Locally cycloplegic drugs such as *atropine sulfate* in appropriate dosage help allay the pain due to irritation of the ciliary muscle. *Desensitization* of the patient to tuberculin and to pigments may be useful. The removal of *foci of infection* should be done carefully if it is thought that

this condition contributes to the inflammation. Various complications such as *glaucoma* secondary to blocking of the drainage angle by fibrous exudates and of the pupil by posterior synechia with production of iris bombe or cataract require special treatment as the indications arise.

PROGNOSIS—The prognosis is poor, useful vision being lost in both eyes in many instances. The watchword in treatment of sympathetic ophthalmia still remains *pre-emption*.

NONTRAUMATIZING OPHTHALMIC SURGERY

Ophthalmic surgery should be as nontraumatizing as possible. Technique should be studied so that a minimum of injury is inflicted during necessary intra-ocular operations. For example, tissues should not be picked up with forceps set free and picked up one or several times more if one application alone can be made to suffice. *Incisions* for cataract and glaucoma should be made accurately, as there is only a small area of safety. The limbus of the cornea is the best location for the incision, but it may be difficult to make it here when the anterior chamber is shallow. It is better to make a small safe incision with a knife or keratome and enlarge this with scissors than it is to incise bravely the full length required and come to grief because of injury to the lens capsule or posterior surface of the cornea in glaucoma or because of a too deeply placed counterpuncture with the cataract knife which has injured the iris and ciliary body. It is better to be able confidently to complete the incision than to find the iris prolapsing on the blade of the knife and haggled unless the knife is withdrawn and the incision completed with the scissors.

One other important source of danger in surgery is the *trauma to the endothelium* caused by rubbing the blades of instruments on the posterior face of the cornea while introducing them into the anterior chamber. In operating upon the posterior segment of the globe a need for care in avoiding injury to the ciliary body is important; the surgeon should measure accurately for the region of the ora serrata and stay posterior to this zone.

INJURIES OF THE EYELIDS

Special Anatomy of the Lids in Relation to Injury—The eyelids are composed of two layers and a margin of

transitional skin. The outer layer consists of skin, orbicularis muscle, lash follicles and their glands of Zeiss and Moll, whereas the inner layer posterior to the gray line of the margin consists of the meibomian glands, the tarsus and the conjunctiva. The upper lid is lifted by the levator muscle attached to the skin at the crease or furrow and the smooth muscle of Muller attached to the tarsus. The lid skin vessels run 2 mm from the edges of the lids. The angle of the internal canthus is somewhat rounded while that of the external canthus is acute. The inner edge of the margin of the lid is squared, that of the outer edge is rounded. The tarso orbital



Fig. 100—Traumatic ectropion

fascia, a continuation of the deep tissues of the lids, is important in its attachments to the orbital margins and to the smooth muscle of the lids.

INCISED SURGICAL WOUNDS—These wounds of the eye lids when not involving the deeper tissues usually heal gracefully and with negligible scar formation. Care must be exercised in suturing so as to leave no deformity after healing.

INCISED ACCIDENTAL WOUNDS—The use of safety glass in spectacles when the worker is subjected to danger and the universal use of safety glass in automobiles is strongly to be recommended. Cases have been seen in which the edge of

the spectacle lens cut the lid by being forced against the orbital margin

PENETRATING OR PERFORATING WOUNDS—These wounds may carry infection and foreign material such as metal glass stone wood and skin including portions of the lid margin and cilia deep into the tissues. If the foreign material is non irritating its presence may be borne well but if it is copper or wood a marked reaction will soon manifest itself

LACERATED WOUNDS—If the full thickness of the lid is vertically lacerated there will tend to be a notching or angu-

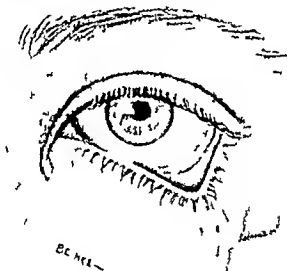


Fig. 101—Castral laceration and a high blepharoplasty from orbital cellulitis (traumatic)

lation. If the scarring is deep seated ectropion (Fig. 100) or entropion is very likely and if the internal canthal ligaments are completely severed a laxity, eversion and lack of coaptation of the lid to the globe will result. *The initial suturing is important.* Lacerations produced by dogs or other animals afflicted with rabies should receive prompt prophylactic anti-rabies treatment.

CONTUSED WOUNDS—These may be destructive in nature causing sloughing of superficial and deep tissues and resulting in coloboma, ectropion, entropion, ptosis, lagophthalmos, symblepharon and ylablepharon or other disfigurement (Fig.

101) Debridement should be employed with caution. Infection may also produce these bad results. Specific sera and treatment may be indicated in cases of erysipelas streptococcus infection syphilis etc.

TREATMENT

FIRST AID—First aid consists in *hemostasis, cleansing, of the wound application of an antiseptic, such as tincture of iodine or mercurochrome coaptation of the wound, and a simple dressing.* As soon thereafter is feasible when brought to the ophthalmic surgeon, preferably one experienced in plastic surgery about the eyelids the wound is again inspected all foreign material is removed fine silk sutures are used where needed and a firm dressing is applied making sure the palpebral fissure is closed. If there is swelling of the orbital tissues it is well to use double armed sutures between the lid margins. These may be placed over small rubber plates fashioned from rubber tubing and turned with the concave side toward the skin best about 3 mm from the margin. If it is anticipated that destructive lesions will produce ectropion it will be best to make intermarginal lid adhesions. These may stretch due to the effect of the contraction of scar tissue but they will protect the globe during the initial healing process.

HEMORRHAGE INTO THE EYELIDS—The appearance of the shiner or black eye as a result of blows about the eye is familiar to all. After a minor operation on the lids as for chalazia the escape of blood into the tissues may give the same appearance. The blood and serum may travel across the bridge of the nose to produce swelling of the lids of the other eye.

The prevention of extravasation of blood and serum into wounded tissues consists in the careful application of pressure and cold immediately after the injury. However, devitalized tissues must not be iced or refrigerated too much since gangrene and sloughing have been known to occur. Cold applications need not be used more than twenty four to thirty six hours after which absorption of the blood and debris will be hastened by the application of warm compresses. A useful prescription for the purpose is as follows:

- 1 Anoint skin around the eyes with lanolin

- 2 Hot compresses of epsom salts (1 tablespoonful to 1 pint of water ten minutes)
- 3 Cool compresses of sodium bicarbonate (1 teaspoonful to 1 pint of water five minutes)
- 4 Eyewash with an eye cup

FOREIGN BODIES—Foreign bodies in the lids are usually small fine pieces of glass sand dirt and powder may well be removed carefully using the point of a knife or spud or curette Powder grains found after explosions are very difficult to remove After a thorough scrubbing of the superficial skin removing even all the epidermis if necessary a small trephine may be used for single deeper grains or an elliptical excision with suturing in the presence of a group of black grains Small foreign bodies beneath the lid embedded in the conjunctiva should be removed before the mucous membrane heals over them

DESTRUCTION OF THE LID MARGIN AND OF EYELASHES—The margin of the lid and line of eyelashes are difficult to replace when they are destroyed If a partial defect is present in the important central or nasal arcis the lash bulb bearing skin tissue may be slid over from an intact area of the temporal portion of the lid margin by splitting the lid at the gray line Free grafts of eyelashes may be obtained from the brows and prove better than a bare lid margin for function and appearance

SUPERFICIAL INFLAMMATION (DERMATITIS)—Care should be exercised in the use of all cosmetics and applications about the eyes for their remote effect upon the eyes and eyelids In the same class are the cases of dermatitis produced by contact with other substances such as ointments used elsewhere on the body which are irritating to tender eyelid skin particularly in those sensitive to their action

Burns of the Eyelids

THERMAL BURNS—Most thermal burns affect only the skin of the lids singeing the lashes and not burning the cornea or conjunctiva because of the rapidity of the reflex of the lids If the effect is only on the epidermis and is that of erythema the condition will heal simply through the application of vaseline or boric ointment If the burn is deeper or of second

degree there will usually be contraction resulting in simple ectropion. In third degree burns, such as the terrific flash burns following gasoline explosion (Fig 102) the victim has no time to close his lids hence the conjunctiva and cornea are involved and the heat is so extreme that the skin and lid margins may be lost producing severe ectropion symblepharon or ankyloblepharon.



Fig 10 -Severe burn (gasoline explosion) resulting in cicatricial ectropion (Courtesy of Dr J H Dunnington)

CHEMICAL BURNS—Chemical burns act similarly to those caused by heat. The chemical should be removed by neutralization if possible and by *copious* *irrigation* with water. Symblepharon (Fig 103) or union of the lid to the globe by scar tissue often results.

The *immediate care* of severe burns is that of protection of the globe. Nonirritating oils, greases and ointments should be used. Albolene and petrolatum, olive oil, lanolin, mixed or made up into bland ointments, are very useful. Protecting shields of metal or of the new cellulose compounds maintain the moisture of the cornea. The after care will depend upon the indications.

One of the authors (D B K.) has found it hardly worth while to sever *adhesions* between lid and globe because these

quickly reform. The daily trauma of tearing them apart results in even more dense adhesions. If the lid can be separated by simply drawing it gently away, all well and good, but there is no point in introducing metal, celluloid, or dental compound to cause further trauma. The final care of burns will be indicated by the sequelae.

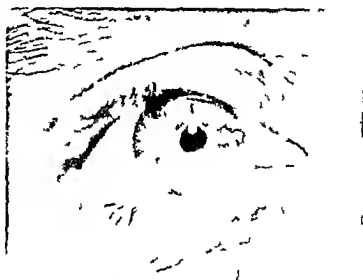


Fig. 101—Symblepharon following chemical trauma.

Lacerations of the Eyelids

HORIZONTAL LACERATIONS—When these involve only the thin skin, particularly of the upper lid, they need no special care. If the laceration is jagged or vertical, care must be taken to suture the margins accurately to prevent the effect of the pull of the orbicularis muscle. Some skin may be sacrificed from the upper lid because there is usually more than sufficient, but very little may be lost from the lower lid without eversion of the margin.

VERTICAL LACERATIONS—Such lacerations, particularly through the margins or deep lid tissues, should be *immediately repaired* and measures taken to prevent notching and other deformities.

Every millimeter of lid margin is valuable and very little can be sacrificed without replacement. Debridement should be exercised with extreme care. A simple vertical laceration

needs *overcorrection* at the margin to prevent notching or angulation. The vertical laceration takes the form of a V, due to spreading of the wound and can be overcorrected by horizontal incisions each one half the length of the vertical laceration then suturing first the apices of the horizontal incisions together. Interrupted through and through horizontal sutures are employed to coapt the remainder of the wound tying them over the skin to one side of the wound. These sutures cause the lid margin to push up into a mound 1 to 3 mm above the normal margin. The margin of the wound



Fig 104—Imperfect healing following tear of lower lid

itself may be held in line by a vertical suture. In the healing process the overcorrection is straightened out into a smooth line. Sutures should not be drawn too tight else they may cut through the tissues. Notching and angulation after healing may be corrected in the same fashion after excision of the cicatrix.

If a vertical laceration through the margin has *ragged edges* and a portion of the skin has been lost exposing the tarsus at the gray line it is well not to cut away the good tarsus but to employ the *halving procedure*. The tissues over the exposed tarsus are cleaned and the opposite edge of the wound is cleaned to form a counterpart. Double armed through and

The *pressure dressing* is a most important part of any operation for the late repair of traumatic eyelid conditions. Over guttapercha which is cut and shaped to fit inside the bony orbital margin is placed a number of gauze fluffs built up in a mound above and within the orbital margins. One inch strips of adhesive plaster are placed to hold the gauze firmly in position. The direction of the first of these is oblique from the center of the forehead down and out below the cheek including the corner of the mouth and pulling the skin together above and below. The others are curved about this line and to the same positions above and below but curved inward the outside of the fluffed gauze. About six such strips are required. Then a 1 inch piece of adhesive is placed quickly across the center of the forehead so that the adhesive portion will later be used to draw up the bandage from the fellow eye. A special perforated (Pfeiffer) pad of thick padded material is then placed over the ear on the side of the dressing. A roller bandage is applied to hold the eye dressing in apposition to the tissues.

The pressure induced should be great enough to prevent extravasation of blood and serum. There should be no local areas of pressure over bone great enough to produce pressure necrosis. If the eye cannot seek refuge in the loose spaces of the orbit other means should be devised to protect the eye and to prevent extravasation.

Operation of the Lacrimal Sac

Purulent dacryocystitis requires correction before lid operations are undertaken. The procedure of *dacryocystorhinoscopy* is *unsuitable* for cases of trauma because of the usual involvement of the ethmoids and the displacement of tissues. Removal of the sac and cleaning out the infected tissues is the only satisfactory procedure.

Marginal Lid Adhesions as an Adjuvant in the Correction of Traumatic Eyelid Deformities

The *protection of the globe is paramount* in the treatment of eyelid injuries. This may be largely accomplished by the removal of intermarginal lid adhesions which will serve the added function of working the lids into plastic form over a pro-

longed period of healing and reconstruction. The adhesions should be used in the correction of ectropion and ankyloblepharon and should not be severed until the movements of the lids with the globe indicate that they are in accurate coaptation with the globe. The adhesions are formed by denuding definite opposing areas about 15 by 4 mm. of each lid margin, and then by splitting the lid slightly in the gray line to a depth of 1 mm. by suturing with double armed silk suture over rubber plates a 2 mm. by 4 mm. dense adhesion will be formed. Usually two adhesions are required. They remain in place for from two to six months during the reconstruction process.

The Correction of Post traumatic Ankyloblepharon and Cicatricial Ectropion

Ankyloblepharon and ectropion are important and serious complications in the healing of injuries of the eyelids. Loss of tissue and contraction of cicatrices are the causes. The surgical treatment is manifestly that of removal of scar tissue and supplying new tissue to replace that which was lost.

The initial incisions in the correction of ankyloblepharon and cicatricial ectropion should parallel the lid margin in its faulty position and be followed by a dissection which frees the lids and removes the scar tissue bands so that the lids may be brought into apposition for intermarginal lid adhesions. The denuded area then evident requires immediate covering with grafted skin to stimulate healing without granulation or more scar tissue formation.

Autoplastic free dermis grafts from the upper lid are ideal. Next best are the cephalo auricular angle free grafts and third best in burns involving both upper and lower lids of both eyes are free epidermal grafts from the thigh. These grafts may be prepared with a special wide razor or with the Padgett¹³ dermatome. If there is no loss of lid margin or of the deep or dense tissue of the lids there is no need for sliding or pedicle flaps.

The Correction of Post traumatic Coloboma of the Eyelid by Sliding Pedicle Graft

A post traumatic coloboma of more than 4 mm. cannot be corrected by apposition of the edges even though relapsa

tion be secured by free external canthotomy. A sliding pedicle flap or graft from the temporal area is usually most satisfactory. Wheeler¹⁴ used the methods both for the congenital and post traumatic forms.

The first incision is from the angle of the external canthus through the skin thickness straight out toward the ear. The second is above or below, starting with a width of about 12 to 15 mm and slanting diagonally, widening above or below as the case may be for repair of upper or lower lid coloboma. Both incisions extend almost to the ear to gain relaxation of tissue. Subcutaneous dissection of the lid tissues and rearrangement of the conjunctiva and necessary advancement to fill the coloboma area and to have complete skin covering externally and conjunctiva covering internally are necessary. The flap is thickened and widened toward the temple. This is important for preservation of circulation and nutrition of the flap. The tip should not be traumatized and the actual union of the ends is often best made by the haling technic.

The Creation of a New Lower Eyelid (Hughes¹)

When the entire lower lid has been destroyed by trauma a very difficult situation presents itself. The sliding flap used for correction of colobomata up to 15 or 20 mm cannot be applied to the restoration of the complete lower eyelid. The old Italian technic of transferring skin from the arm and the cumbersome pedicle flaps from the forehead are too deforming and unsatisfactory. The skin does not match and there is a tendency to sinking of the edges and bulging in the center of the graft.

A technic which appeals to the authors as applicable to this condition is that which *Hughes* has used most successfully after removal of the lower lid for neoplasms. The upper lid is split completely along the gray line. The inner side with its conjunctival lining and tarsal support is denuded of its margin and carried down to its new position to form the inner half of the lower lid. The outer part with the skin and lashes is maintained by sutures so that the margin is on the line of the canthus. This upper portion retains the levator and smooth muscle of the upper lid. The skin defect below is relieved by sliding up a superficial flap from below. When all have healed

A new palpebral fissure is formed by opening into the conjunctival sac just below the line of the margin and the lashes of the upper lid. New lashes may be grafted to the reconstructed lower lid if desired. The results are very satisfactory.

The Correction of Traumatic Symblepharon

Symblepharon or union of the globe and eyelids develops after a burn or other trauma which destroys conjunctival and subconjunctival tissues. If correction is possible *sliding conjunctival grafts* are the best. Free buccal mucous membrane grafts have been used. Even in the most satisfactory cases the results are unsatisfactory. Shallow conjunctival fornices or cul de sacs have been deepened by suturing a graft in position and then anchoring it deeply by passing double armed sutures through it and out through the skin tying them over rubber plates.

Pseudotumor and Tumor Formation after Injury

Some patients react to any trauma with blood formation hypertrophy and infiltration of subcutaneous tissue occurring. Some of these pseudotumors regress and absorb spontaneously. Others react well to the application of gamma rays administered by a radiotherapist. Repeated trauma may be responsible in some cases for neoplastic formation although the relationship is not always clear.

INJURIES OF THE ORBIT AND EXTRINSIC OCULAR MUSCLES

Contusing wounds of the orbit may cause various paralyses and atrophies including absorption of the orbital fat enophthalmos and loss of function of the eye. Penetrating wounds may cause orbital infection with its attendant bad results.

A condition arising from blasts and explosive bombs from air raids and other war accidents is that of many foreign bodies embedded and perforating and that of the effect of sudden compression and expansion of the atmosphere. Proptosis with retrobulbar hemorrhage with immediate loss of vision and later the appearance of optic nerve atrophy, extensive intra ocular hemorrhage ruptures and holes of the macula of the retina with loss of central vision and other similar phenomena have been reported.

Fracture of the skull may cause orbital hemorrhage and paralysis of extraocular muscles particularly of the external rectus muscle because of the long exposed course of the sixth cranial nerve. In the case of an aviator who developed a paralysis of the left abducens following a crash Berens¹² succeeded in correcting the paralytic esotropia with loss of binocular vision diplopia and complete inability to fly by receding the internal rectus muscle and performing a transplant of half of the superior and inferior recti to the stump of the paralyzed externus. The aviator was reaccepted for military flying in a foreign service.

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FRACTURES OF THE SPINE

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EXCELLENT papers on all aspects of fracture and fracture dislocation of the spine are available in the literature but a compact review of this subject stressing the forms of treatment which may be used under war conditions is perhaps timely.

During the past five to ten years certain points in the treatment of such cases have been emphasized (Browder). Perhaps the most important of these are the proper early handling and transportation of the patient from the scene of the accident, the preference for skeletal traction over reduction with the halter in fracture dislocations of the cervical spine and the advisability of early reduction of almost all thoracic and thoracolumbar fractures with early immobilization in plaster in the uncomplicated cases. In addition to this it has become clearer which cases can be benefited by surgical intervention.

EARLY DIAGNOSIS AND MANAGEMENT

Early Diagnosis

When the type of accident is such that it could cause injury to the spine it is wiser to treat the patient as though he has a fracture until this is ruled out. The early signs may be only pain or tenderness over the spine and if he is unconscious even this is absent. Of course if gross paralysis or weakness of the extremities is present the diagnosis is usually obvious. The differential diagnosis between fracture of the lower cervical vertebrae and those of the thoracic and lumbar regions even in the presence of cord involvement is not how-

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ever always easy and this must be kept in mind when deciding whether to transport the patient in the prone or supine position. Unless a fracture or fracture dislocation of the spine is suspected of being present the patient will obviously not be treated for this and irreparable damage to the spinal cord or *cruda equina* may result from improper handling.

Early Handling and Transportation of the Patient

We would strongly urge that the basic principle of splint them where they lie be applied equally to fractures of the spine as it now universally is to fractures of the long bones. In any suspected case of spinal injury a good procedure is to place the patient flat on his back and leave him in this position until transported. In establishing the patient in this position the initial posture in which he is found must be taken into consideration. If the spine is obviously flexed or rotated or in any manner distorted from the axial line one must as a primary procedure by gentle traction and countertraction establish an extended posture. Following this when the patient is being moved never flex or rotate the spine but treat him as though he is a rigid fixed object like a glass pipe.

For transportation a stretcher or preferably a flat object like a wooden door or plank may be used. However we would definitely advocate that where possible the movement of the body en masse so necessary for maximum safety should be facilitated by firmly binding the entire torso and head to long splints. If one is certain that the injury is in the thoracic or lumbar region the stretcher can be placed beside the patient and he can then be rolled over onto this on his stomach care being taken that the shoulders and pelvis rotate in the same plane and that the spine is not flexed (Stool ey). If the injury is in the cervical region the patient should be placed on his back on the stretcher the same precautions against flexion or rotation of the spine being taken. To accomplish this four people are usually required to lift the patient or the stretcher is placed at the injured's feet parallel to him and with the aid of traction on the ankles and gentle continuous countertraction through the chin and occiput he may be slowly drawn onto it.

In fracture of a lower cervical vertebra marked paresis of the legs may be present with only moderate weakness of the hand grips. Such a case can easily be mistaken for a fracture of a dorsal or lumbar vertebra and if the patient is transported in the prone position with the head rotated to one side permanent or fatal injury to the cervical spinal cord may be caused. Consequently when there is any doubt concerning the presence of a cervical fracture it is well to transport the patient on his back. Patients with dorsal and lumbar fractures are moved with safety in this position on a flat resistant surface if flexion is avoided. This may be more adequately accomplished if a blanket roll or other relatively soft object is placed beneath the back to create extension at the site of fracture.

In view of the difficulty of diagnosing the level of the fracture on the field *we believe that the safest general rule is to transport all these patients on their backs* in the method described.

We would here suggest that when time and circumstance permit it is possible and even desirable to mold single or bivalved shells at the site of accident prior to transportation.

Handling of the Patient on Admission to the Hospital

A good method is to leave the patient on the stretcher do an immediate complete neurological examination and palpate the local condition without changing his position if this is satisfactory. Then bring him directly for x-ray examination (provided shock is not present). This should be conducted wherever possible without moving the patient from the stretcher. To get lateral films of the lower cervical vertebrae manual traction must usually be applied to the patient's wrists to pull the shoulders down. In heavy set short necked individuals it is sometimes virtually impossible as an emergency procedure to obtain an adequate view of the seventh cervical vertebra. In such circumstances we feel that fracture precautions should be maintained until adequate films can be taken.

When the diagnosis has been made treatment should be immediately instituted. If the patient is to be lifted to a bed or operating table four people are required. One can apply manual traction to the occiput and chin another traction to



A



B

Fig. 105—A Reduction of cervical dislocations and fractures by elastic traction through an occipitomenal halter. The halter made from a 6 inch muslin bandage. Traction is exerted by several turns of an Estmarch rubber bandage. Note the spring lance which in this particular case registered 50 pounds traction. Also observe the anterior plaster of paris shell which has been molded while the patient is under traction. The patient is instructed to keep his mouth open or if he is under anesthesia it is kept open with a wooden wedge. The collar is molded so that the traction pressure is at the angle of the jaw (marked x) and not at the point of the chin. This method makes it possible for the patient to masticate with comfort. The pencil in slot shows the cast should be trimmed to leave the ear free from pressure. This is most important for pressure on

the ankles and the third and fourth place their arms under the pelvis and shoulders respectively the patient being lifted as a rigid object as stressed above. If laminectomy is the elected procedure the patient can best be splinted before turning to the prone position on a rapidly molded anterior plaster of paris shell (Fig 105, A)

Treatment

Treatment should be directed toward prompt reduction of the deformity and maintenance of the spine in a hyperextended position. The object of this is to restore the normal alignment of the bony parts and thus to prevent immediate or late pressure on the spinal cord cauda equina or nerve roots and to avoid pain as a late sequela of incomplete reduction. To accomplish this overcorrection of the deformity in extension is usually necessary. The methods employed differ according to the location of the fracture and whether or not gross neurological loss of function is present. The discovery that the very strong anterior common ligament is the check to over hyperextension has dissipated the natural fear felt by many operators that extreme hyperextension involved the danger of cord and root damage (Davis)

SPECIFIC INJURIES

Rotary Dislocation of the Axis

Jackson in 1927 reviewed the subject of simple unilateral dislocation of the axis and pointed out that the condition is often undiagnosed because it may be produced by violence of such a minor nature that the attending physician fails to conceive of the possibility of its presence.

The lateral joint surfaces of the atlas and axis are of the nearly flat sliding type and oppose each other in an almost

the auricle may produce a serious decubitus. After the anterior portion of the plaster is hardened it is strapped to the patient and he is turned on his face (with the traction still functioning) and the posterior articulating shell is made or if necessary laminectomy is performed.

B The posterior portion of the plaster has been completed and the two shells firmly joined together. Note that the cervical spine is held well hyperextended by the dressing but nevertheless the patient is able to open his mouth. Note also that for better cervical retention the plaster of paris dressing extends down to the pelvic crest.

horizontal plane in such a way as to allow rotary movements of the head. When the neck musculature is relaxed the head may easily be rotated in the full functional limitation of these articulations. If at such a time the head is accidentally rotated further there may result a rupture of the capsular ligament of one of the atlanto-axial articulations and a slipping forward of the articular facet of the axis into or over the anterior marginal lip of the facet of the axis.

The characteristic symptoms of such an injury are persisting pain, tenderness and stiffness in the neck, inability to open or difficulty in opening the mouth, impairment of rotary movement of the head on the neck and deviation of the chin to one side. Palpation over the posterior neck and through the pharynx may reveal a characteristic deformity. In simple unilateral dislocation without fracture there is no cord injury. X-rays will usually clinch the diagnosis but it is at times difficult to rule out an additional fracture of the odontoid since X-ray views cannot be taken through the mouth because of the patient's inability to open it.

Reduction of a simple unilateral dislocation of this type as a rule can be accomplished by *halter traction* (Fig. 105 A). Manipulation of the neck is carried out with ease at the same time. An anesthetic will facilitate the procedure by relaxing the muscles but is not always necessary. When reduction has been accomplished an X-ray view to rule out fracture of the odontoid must be taken through the open mouth. This should be done where possible while maintaining traction. Otherwise it may be carried out after a cast or collar has been applied. McKenzie favors a Thomas plaster collar (or leather collar). Recurrences have been reported in a collar but as he points out it is worth a trial as it is more comfortable than a Minerva jacket which must be expertly applied to be efficient. Immobilization of this type should be maintained for at least two to three months.

Simple unilateral dislocation at lower cervical levels is uncommon owing to the overlapping of the articular facets.

If a fracture of the odontoid is present one is faced with the likelihood of progressive atlanto-axial dislocation. The treatment of this condition will be described later.

Bilateral Dislocation Fracture and Fracture dislocation of the Cervical Vertebrae

A number of methods have been used with satisfaction in the reduction of traumatic deformities of the cervical vertebrae. Perhaps the one most commonly employed especially in the past is reduction by means of a halter (Fig 105 A). The disadvantages of this type of traction are that it cannot be maintained for more than a short period without causing discomfort to the patient, difficulty in respiration and opening the mouth and pressure sores over the occiput and lower jaw. If a properly supporting cast or bivalved shell is applied after the reduction the results may be satisfactory but there is frequently danger of recurrence of the deformity.

Manual reduction under anesthesia as employed by Taylor with immediate immobilization in plaster has given good results but there is undoubtedly danger of injuring the cord during the maneuver and here again it is difficult to maintain the reduction even in a well applied jacket.

Stokey's method of hyperextending the neck on an air mattress and allowing the head to hang down on an inclined plane is as a rule useful in only mild deformities where little traction is required for reduction. He himself states that he has abandoned the method in most cases for that of skeletal traction.

It is now almost uniformly accepted that *skeletal traction* is the method of choice in the treatment of most traumatic deformities of the cervical spine whether or not neurological signs are present (Crutchfield, Burton, Hoen, Cone and Turner, McKenzie, Browder and Grimes and others). The advantage of this method is that any amount of traction may be applied continually for an indefinite time. During this period the patient is comfortable and can be turned in bed which facilitates the care of the skin and the handling of bed pans. While traction is in place there is little or no danger of secondary displacement and this can be avoided later if the traction is maintained for a period long enough to allow partial union of the injured structures.

The different types of skeletal traction available are those of Crutchfield, Burton, Hoen, Cone and Turner. Crutchfield's tongs are highly satisfactory and can be applied quickly with

out danger. After proper preparation of the scalp a stab wound is made over each parietal region in line with the mastoids at a distance indicated by the width of the tongs. A small drill hole is then made in the bone at the site of each incision with the drill point provided. This has a small guard 4 mm from the point which prevents the drill perforating the inner table of the skull. The traction points are placed in these small perforations and tightened into position by screwing the limbs of the tongs together. The desired amount of traction (15 to 20 or more pounds) is then applied as indi-



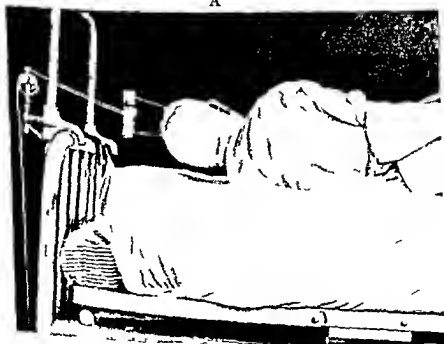
Fig. 106—Skeletal traction by means of Barton's tongs for fractures and dislocations of the cervical vertebrae. (See text.)

cated in Figure 106. If dressings are properly placed over the two incision wounds and changed daily there is little or no danger of infection occurring.

Barton's tongs are equally serviceable and are applied over the parietal bosses in a similar manner (Fig. 106). These tongs have the advantage of entering the skull at right angles and there is perhaps less danger of them pulling loose when heavy traction is used. When tongs are not available a highly satisfactory form of applying skeletal traction is that described by Hoen and by Cone and Turner. We have used



A



B

Fig 107 -A Skeletal traction wires in place. Note that they pass through burr holes in the skull. B Skeletal traction by means of wire passed through burr holes in the frontal region. The wire is indicated by the inked lines. (See text)

this method in six cases of fracture dislocation in the cervical region during the past year with excellent results and no infections. An example of the method is shown in Figure 107 A B and it is completely described in the articles of Hoehn and Cone and Turner. It should be a useful form of treatment during wartime where tongs may be hard to obtain.

Skeletal traction is maintained in the majority of instances for at least five weeks even though signs of cord injury are absent. A cast shell or brace may then be applied and should be worn for four to six months or more. If there are minimal or no neurological signs the patient is allowed to be ambulatory; otherwise he is kept in a wheelchair or propped up in bed. If the neurological involvement is severe a bivalved plaster shell is a good form of immobilization when traction is to be discontinued since it permits proper attention to the skin or the patient may be placed on an air mattress with the neck in extension as described by Stokes.

Thoracic Injuries T₁ to T₁₂ (Without Spinal Cord Involvement)

The upper thoracic vertebrae are fractured much less often as a result of indirect violence than are those of the cervical or thoracolumbar region.

In simple anterior lip or in mild crush fractures of the centrum the thoracic spine should be immobilized in moderate hyperextension in a jacket. This can be applied by the foot suspension method with the patient in the prone position on a canvas strap or in the manner shown in Figure 108. These methods realize the ideal mechanics in producing hockey stick hyperextension (Davis).

In more severe crush fractures of the centrum reduction usually requires fixation in a marked degree of hyperextension. This may be accomplished either by foot suspension or perhaps better by the procedure illustrated in Figure 109. This method was devised to replace the sometimes dangerous automobile jack form of extension. A wooden splint is soaked in water and molded in an arc (similar to that shown in Figure 110). Plaster is applied to it and two strips of felt laid parallel along the convex surface of the plaster covered splint. The patient is then lifted as a rigid object by four people and the apex of the convex surface placed at the site of fracture.

the strips of felt being applied in such a position that they lie along each side of the spinous processes thus protecting them from pressure. A canvas or gauze strap is passed about the patient to include the splint. The patient is now elevated in the manner shown in Figure 109 his thoracic spine gradually molding itself to the convex surface of the splint as the head and shoulders fall into a dependent position. When the thoracic spine has reached the desired degree of hyperextension a plaster cast or bivalved shell is applied. This should include the shoulders. There is a difference of opinion con-



FIG 108.—Reduction of lower thoracic and lumbar fractures can be easily effected by suspension in the manner illustrated. A posterior plaster of paris shell has been molded in this lordotic posture. Note the plaster ribs added posteriorly for the purposing of adding strength to the shell. When this shell is firmly set it is strapped to the patient (see Fig 111) and he is turned on the shell to a dorsal decubitus position and an articulating anterior section is molded.

cerning the period of recumbency required for these patients. Jones believes in getting them up immediately whereas others are strongly in favor of keeping them in bed for six to eight weeks. The cast or brace should be worn for four to six months.

Injuries of the Lower Thoracic and Lumbar Vertebrae T_{12} to L_1
(Without Spinal Cord Involvement)

The principles involved in the treatment of fractures of these vertebrae are much the same as those for fractures in

this method in six cases of fracture dislocation in the cervical region during the past year with excellent results and no infections. An example of the method is shown in Figure 107 *A B* and it is completely described in the articles of Hoen and Cone and Turner. It should be a useful form of treatment during wartime where tongs may be hard to obtain.

Skeletal traction is maintained in the majority of instances for at least five weeks even though signs of cord injury are absent. A cast shell or brace may then be applied and should be worn for four to six months or more. If there are minimal or no neurological signs the patient is allowed to be ambulatory; otherwise he is kept in a wheelchair or propped up in bed. If the neurological involvement is severe a bivalved plaster shell is a good form of immobilization when traction is to be discontinued since it permits proper attention to the skin or the patient may be placed on an air mattress with the neck in extension as described by Stooler.

Thoracic Injuries T_1 to T_{12} (Without Spinal Cord Involvement)

The upper thoracic vertebrae are fractured much less often as a result of indirect violence than are those of the cervical or thoracolumbar region.

In simple anterior lip or in mild crush fractures of the centrum the thoracic spine should be immobilized in moderate hyperextension in a jacket. This can be applied by the foot suspension method with the patient in the prone position on a canvas strap or in the manner shown in Figure 108. These methods realize the ideal mechanics in producing "hockey stick" hyperextension (Davis).

In more severe crush fractures of the centrum reduction usually requires fixation in a mild degree of hyperextension. This may be accomplished either by foot suspension or perhaps better by the procedure illustrated in Figure 109. This method was devised to replace the sometimes dangerous automobile jacket form of extension. A wooden splint is soaked in water and molded in an arc (similar to that shown in Figure 110). Plaster is applied to it and two strips of felt laid parallel along the convex surface of the plaster covered splint. The patient is then lifted as a rigid object by four people and the apex of the convex surface placed at the site of fracture.

the upper thoracic region. The chief difference is that the maximum hyperextension at the time of reduction must be applied in the thoracolumbar region and the cast or shell used does not have to include the shoulders. Davis points out that the normally hyperextended spine is shaped like a hockey stick, the handle of which is represented by the relatively inflexible dorsal segment and the crook by the lumbar section. In reducing a fracture in the thoracolumbar region one should con-



Fig. 110—The reduction of lower dorsal and lumbar compression fractures by means of suspension by the feet. It should be observed that the feet are well padded with cotton sheet wadding to avoid any injury from the suspension straps. The application of the plaster of paris corset is easily effected in this position.

sequently strive to have the maximum extension at this site as is the case in the normal spine. This is probably best accomplished by using the foot suspension method with the patient lying on a canvas hammock. When the latter is not available which it may not be under war conditions, the patient may be satisfactorily extended as shown in Figures 108 and 110. Manual manipulation can be carried out during either of these hyperextension procedures. Another method that could

be used even in the field is illustrated in Figures 111 and 112. Most surgeons keep these patients in bed for two to three months but Jones reports good results in patients whom he has allowed up immediately after the application of a cast. The cast or spinal brace should be worn for seven to eight months.



Fig. 111.—Upper. A simple method of producing hyperextension in the lower dorsal and lumbar regions. Sandbags are placed under the pelvis and the torso is thus lifted permitting the spine to assume position of lordosis. In this position the vertebrae are held and supported firmly to the body.

Lower. The patient is lying on the dorsal recumbent position and an artificial gaiter is still been indicated. The patient is now turned to the side and lying off the upper half of the body may be expected a day or two. This system of artificial shells is particularly useful in the case of the indelible pencil mark which is placed across the middle of the edge of the shells. The marks of the ribs in properly placed, the shell fits the body.

Fractures of the Thoracic and Lumbar Spine (With Spinal Cord Injury)

When signs of spinal cord damage are present in injuries of the thoracic or lumbar vertebrae the same objects of treatment should be fulfilled as described for uncomplicated cases. Reduction of the fracture must be accomplished to prevent continued compression of the cord. This compression is

usually due to pressure exerted by the upper posterior margin of the fractured centrum and to overcome this or prevent it recurring prolonged hyperextension as a rule is required

The deformity should therefore be reduced by one of the methods described above. If neurological signs are minimal a cast may then be applied but should the cord damage be more severe great care of the skin is required to prevent pressure sores and this method is unsatisfactory. To maintain



Fig. 11.—The patient of Figure 111 is standing well supported in lordosis by the double shells which are firmly held together by fabric buckle straps.

hyperextension in these cases the patient can be put in a bivalved shell (see Fig. 111 lower) or mildly hyperextended on an air mattress by placing a blanket roll under the mattress at the point of fracture (as described by Stookey). As bed sores are most likely to appear over the sacrum the patient may be kept in the prone position and hyperextended by elevating the gatch at the head of the bed. The optimum period for application of a cast will depend

upon the degree of neurological dysfunction. He should in bed for at least three months.

Fractures of the Sacrum

Fractures in this region are relatively uncommon. If the fragments are not displaced, bed rest for two to three months on an air or sponge rubber mattress is usually sufficient treatment. If indriven fragments are present, operation may be advisable.

INDICATIONS FOR OPERATIVE INTERVENTION IN SPINAL INJURIES

It is quite generally agreed that laminectomy is of value in only a small fraction of the cases of fracture-dislocation or fracture-dislocation of the spine (McKenzie, Elsborg, Browder and Grimes, and others). There are, however, certain cases in which this procedure alone or combined with fusion is indicated.

Progressive atlanto-axial dislocation is a condition requiring surgical intervention. It is due to a forward displacement of the atlas on the axis with fracture of the odontoid process. The forward displacement at first may be very slight and neurological signs absent. Immobilization or traction and immobilization may be tried at this stage, but if signs of progressive dislocation appear, which is frequently the case, fusion of the occiput to the cervical spines must be carried out. If the condition has been allowed to progress to the stage in which pressure on the spinal cord is apparent, removal of the arch of the atlas should be combined with fusion (see Cone and Turner, and Kahn and Iglesias).

Among the cases of *acute spinal injury*, most surgeons are of the opinion that operation should be restricted to that small group of patients in whom pressure is being exerted on the spinal cord or cauda equina by a fragment of bone which cannot be dislodged by manipulative or hyperextension methods. In such cases, decompressive laminectomy with removal of the fragments causing pressure may be beneficial, especially when it is the cauda equina that is involved. Of course, if one feels sure that the spinal cord has been completely destroyed at the site of injury, operation is contraindicated.

In addition to these cases Cone and Turner believe that in *cervical injuries* fusion (and skeletal traction) is the method of choice when more than one of the bony structures is injured or when in high cervical lesions paralysis of the neck muscles due to cell involvement of the anterior horns is present.

After the acute stages of the injury have subsided operation is usually indicated in those cases in which despite reduction of the deformity and maintenance in hyperextension signs of *progressive cord or cauda equina pressure* persist and are accompanied by evidence of *subarachnoid block* on manometric studies.

Patients with neurological signs of cord or cauda compression, a subarachnoid block and x-ray findings of a healed deformity which cannot be corrected by manipulation or hyperextension are also candidates for operation. The prognosis for improvement depends upon the time elapsed since the injury and is much better in cases of cauda equina than cord compression.

Browder and Grimes point out that subarachnoid block in itself is not sufficient evidence for laminectomy as they have demonstrated its presence in a patient seven days after injury in whom there was progressive improvement in function of the involved extremities and no x-ray evidence of abnormalities of the vertebrae.

Operative intervention in cases of herniation of the nucleus pulposus and gunshot or shrapnel wounds of the spine will not be discussed in this paper.

NEUROLOGICAL PRINCIPLES IN SPINAL INJURY

The question of the degree of injury to the nervous structures is of major concern from a therapeutic and prognostic standpoint. When deciding therapy one of the most important problems that confronts the surgeon is whether the spinal cord or cauda equina has been completely and permanently interrupted or retains tissue that is capable of functioning. Fortunately the neurological dysfunction following injury is often partly a transitory one and not due to permanent or game damage. In the presence of an acute apparently complete transverse lesion of the cord therefore one should err

reflex. There is a decided difference of opinion concerning the best method of treatment in these cases.

Three good methods are available: (1) regular catheterization followed by irrigation of the bladder with an antiseptic solution; (2) an indwelling catheter in conjunction with a Y tube arrangement for bladder irrigation; Munro's tidal drainage or McKenna's apparatus; (3) manual expression of the urine by suprapubic pressure on the fundus of the bladder.

The first method is a good one in those cases in which early return of voluntary voiding is to be expected. The technic, however, must be meticulous and the bladder emptied every six to eight hours. If it is allowed to become overdistended the mucous membrane will be damaged and this predisposes to infection.

Where the injury to neural structures is more severe, one of the second methods is used by most surgeons. In this case the bladder is best emptied every six to eight hours to facilitate the appearance of an automatic reflex.

The third method has proved highly successful with some (Browder and Grimes). It avoids the introduction of infection from the outside and allows automatic micturition an opportunity to develop. It should, however, be carried out only by one well instructed in the maneuver. In the early stages after the injury when the internal sphincter is tonically contracted, great care must be taken not to damage the bladder wall by too forceful pressure. (We have seen a bladder ruptured in this manner.) Browder and Grimes point out that it is better to express the urine at the time when the bladder has reached a point half way between the symphysis and the umbilicus rather than at stated intervals, since this will aid in the establishment of reflex emptying. This is the ideal, of course, but very frequent observations of the bladder are necessary, as well as rigid regulation of the fluid intake.

Care of the Bowel

Retention of feces due to loss of sympathetic reflexes is usual when there is severe injury to the cord or cauda equina, but automatic emptying of the rectum occurs later. In the early stages the internal sphincter is contracted and daily irrigation and siphoning off of the contents with a large tube is

indicated. This must be done without changing the position of the patient unless he is in traction or a cast. Impaction of feces should always be watched for and mineral oil is useful to soften the stools. If distention is present a rectal tube and the use of prostigmine are helpful.

General Care of the Skin and Musculature in the Presence of Neural Injury

Pressure sores and contractures such as footdrop are the complications that are apt to develop in this sphere. The skin will break down very rapidly if subjected to pressure when the sympathetic reflexes are abolished, and the patient will not be aware of this if there is sensory loss.

Patients with lesions of the spinal cord or cauda equina should, therefore, all be placed on an air or sponge rubber mattress. If the patient is suffering from an injury to the cervical cord and is in skeletal traction the problem is relatively simple, since he can be turned frequently (every two or three hours) the skin gently massaged alcohol applied and later powder.

Patients with fractures in the dorsal or lumbar region are more difficult to treat but they may be turned very slightly every two hours. The hand should be gently slipped beneath them at the same time and the skin massaged over all bony prominences. These patients do well if placed in extension in the prone position in the early stages thereby keeping weight off the sacrum. Pressure on the anterior-superior iliac spines can be avoided by frequent slight rotation of the patient from one side to the other. Patients with fracture of a thoracic or lumbar vertebra are also treated to advantage in a bivalved shell which permits frequent rotation and easy access to the skin.

We should stress in the interest of skin protection the use of *bivalved plaster-of-paris shells*. A few words may be here interpolated regarding the application of this useful device. It should be realized that skin injury is most prone to occur when pressure is unevenly distributed on the integument. The plaster shell must, therefore, be molded smoothly over a minimal padding of thin felt or flannel. If the patient is unusually thin it is permissible to add a small amount of addi-

tional padding over subcutaneous bony prominences. A smoothly applied though thinly padded shell will be comfortable and safe. It may be parenthetically noted that the ancient Romans reclined on marble couches contoured to the body and highly polished. The smooth equally distributed pressure was probably akin to that of a smoothly molded plaster shell. The respective halves of the shell so made should be marked with an indelible pencil to indicate the proper points of articulation (see Fig. 111 lower). This will enable the nurse to apply the shells in proper juxtaposition as shown in the illustration. Fabric buckle straps are used to hold the shells firmly together. In such an articulated system the patient can be turned from prone to supine position frequently. This permits the nurses to remove the upper portion of the shell and cleanse and massage the skin. Such frequent turnings will materially lessen the twin dangers of hypostatic pneumonia and hypostatic edema of the skin. It is obvious that this latter complication predisposes to decubitus. We would emphasize the fact that the use of the bivalved plaster shell is possible in fractures located at any portion of the spinal axis.

When the patient is on his back pressure on the heels must be prevented. This can be accomplished by placing a small pillow or blanket roll beneath the calves. The knees should be kept slightly flexed by putting another pad under the lower thighs. If the bedclothes are allowed to weigh upon the feet they will help to bring about footdrop. They can be supported by a cradle or a board at the foot of the bed. A pillow or other padding placed between this board and the feet will keep these in dorsiflexion and avoid footdrop.

Massage of all the involved musculature should be started early and passive movement of the extremities when it does not cause too much discomfort to the patient.

SUMMARY

1. Fractures of the spine and suspected fractures thereof should be initially handled on the splint them where they lie principle.

2. In view of difficulties and pitfalls of accurate diagnosis on the field it is safest to transport all patients with such

fractures in the dorsal decubitus position with the lumbodorsal spine supported in lumbar lordosis. The cervical spine must be immobilized in midposition and in extension during such transportation.

3 All spinal fractures should be treated as an emergency once diagnosed.

4 The use of skeletal traction for reduction of fractures and dislocations of the cervical spine is strongly advocated.

5 The anatomical reduction of compression fractures of the lumbar and dorsal spine is safe and in most instances possible and should be effected immediately.

6 Operative intervention is indicated only in a select group of cases.

7 The care of the paralyzed bowel and bladder is of paramount importance.

8 The use of the bivalved plaster of paris shell is advocated in certain cases with neural injury for effective retention of position as an aid to adequate skin and bowel hygiene and to prevent hypostatic pneumonia.

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tional padding over subcutaneous bony prominences. A smoothly applied though thinly padded shell will be comfortable and safe. It may be parenthetically noted that the ancient Romans reclined on marble couches contoured to the body and highly polished. The smooth equally distributed pressure was probably akin to that of a smoothly molded plaster shell. The respective halves of the shell so made should be marked with an indelible pencil to indicate the proper points of articulation (see Fig. 111 lower). This will enable the nurse to apply the shells in proper juxtaposition as shown in the illustration. Fabric buckle strips are used to hold the shells firmly together. In such an articulated system the patient can be turned from prone to supine position frequently. This permits the nurses to remove the upper portion of the shell and cleanse and massage the skin. Such frequent turnings will materially lessen the twin dangers of hypostatic pneumonia and hypostatic edema of the skin. It is obvious that this latter complication predisposes to decubitus. We would emphasize the fact that the use of the bivalved plaster shell is possible in fractures located at any portion of the spinal axis.

When the patient is on his back pressure on the heels must be prevented. This can be accomplished by placing a small pillow or blanket roll beneath the calves. The knees should be kept slightly flexed by putting another pad under the lower thighs. If the bedclothes are allowed to weigh upon the feet they will help to bring about footdrop. They can be supported by a cradle or a board at the foot of the bed. A pillow or other padding placed between this board and the feet will keep these in dorsiflexion and avoid footdrop.

Massage of all the involved musculature should be started early and passive movement of the extremities when it does not cause too much discomfort to the patient.

SUMMARY

1. Fractures of the spine and suspected fractures thereof should be initially handled on the splint them where they lie principle.

2. In view of difficulties and pitfalls of accurate diagnosis on the field it is safest to transport all patients with such

THE SURGICAL TREATMENT OF HERNIATED NUCLEUS PULPOSUS

ALAN D SMITH MD FACS

ALTHOUGH it is quite generally recognized that there are many causes of sciatica and that primary neuritis of the sciatic nerve is seldom or never one of them accumulated experience indicates that by far the commonest cause of this type of pain is herniation of a nucleus pulposus producing pressure on one of the lumbar nerve roots Arthritis strain from instability of the lumbosacral joint myofascitis and contracture of the fascia lata all play a part but apparently an insignificant one compared with herniation of the nucleus pulposus

When it has been established that protrusion of the central portion of the disk is the cause in any given case it is recognized that the best method of treatment is removal of the herniated cartilage Not only is this the most certain means of curing the symptoms but it is the only treatment that assures any permanency of cure Spine fusion is indicated as well in many cases but only in conjunction with removal of the herniated nucleus As will be developed later this operation alone cannot be depended upon to relieve sciatica caused by herniation of a disk Its value in the treatment of low back pain caused by instability of the lumbosacral joint has been well established and accepted

Operation for Removal of a Herniated Intervertebral Disk

The operative technic for removal of a herniated intervertebral disk has been improved and perfected to a large extent within the past few years The earlier efforts to approach this lesion involved a formal laminectomy with removal of the central portion of the arch as far lateral as the posterior articulations The dorsal and then the ventral dura

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were opened and the herniation removed. Because the herniation usually is in the posterolateral portion of the disk, this approach in many cases was not the most direct and indeed the operation was often quite difficult. As experience demonstrated that the lesion was really lateral to the dura in most instances, it was realized that the latter could be retraced medially with the involved nerve root and the operation performed without opening the dura at all. This led to removal of the lamina on one side only. More recently it was realized that because the herniation is at the interlaminar level, removal of the *ligamentum flavum* on the side of the lesion with a very small portion of the adjacent laminae frequently without the removal of any bone at all gains an adequate exposure of the herniation. The procedure has been adopted by Dr. Edwin Deery at the New York Orthopedic Hospital as well as by several other neurological surgeons. Not infrequently it is found that the *ligamentum flavum* is thicker than normal and that it contributes to the pressure on the nerve root. It is suggested that this hypertrophy of the ligament may be a result of instability of the joint. The simplification of the operation and the preservation of the vertebral arch means that the intervertebral joint is left more stable in those cases in which it is decided not to do a fusion, and that where fusion is done it is performed more easily and surely. *In all cases care is taken not to remove any of the articular processes.*

Removal of a herniated nucleus pulposus by the method just described usually is fairly simple in the hands of an experienced surgeon. It is possible to get the patient up in from two to three weeks and out of the hospital in a short time thereafter. Such is the course of an uncomplicated case with a history of sciatica and no antecedent back pain and with normal lumbosacral architecture.

Indications for Spine Fusion in Conjunction with Removal of Disk

The question which is concerning orthopedic surgeons in particular and which should be in the minds of all others who treat these patients is when should a spine fusion be done in addition to removal of the herniated cartilage. In general this may be answered by stating that it should be done *when*

either there is an unstable lumbosacral joint Of course many considerations such as the patient's age and condition of health may influence the decision in each individual case. The history is of value insofar as it supplies information on whether or not back pain as distinguished from sciatica has been present and if so for how long. If the sciatica was sudden in onset and of only a few months duration without backache one would be less inclined to perform a fusion.

What constitutes instability of the lumbosacral joint appears to be susceptible to wide variation among different orthopedists and clinics and hence the practice in regard to spine fusion in these cases differs greatly among various surgeons. Some of the more important factors which produce a weak lumbosacral joint as accepted by the staff of the New York Orthopedic Hospital are these: (1) an acute or exaggerated lumbosacral angle (2) anteroposterior or asymmetrical lateral articulations (3) posterior displacement of the fifth lumbar vertebra (4) lateral defects in the laminae with or without forward displacement of the vertebra (5) thinning of the intervertebral disk. One or various combinations of these may be present and their importance must be weighed in conjunction with the history, the patient's age, general condition and so forth in deciding upon the necessity for a fusion. There is no doubt in our minds that in the great majority of cases in which such a condition exists with a herniated disk fusion should be done.

Because these cases practically always include problems which combine both neurological and orthopedic techniques it has been our practice at the New York Orthopedic Hospital from the start to have them managed by a team including a neurologist, neurosurgeon and orthopedist. The preliminary examinations are carried out by both the neurosurgeon and the orthopedist and both participate in the operation. It is our conviction that this close cooperation has worked to the best advantage of the patient in securing the best solution of the problem.

The next question which is demanding an answer is whether a fusion should be done in practically all cases in which a herniated nucleus is removed. In our early management of these cases we took the stand that a fusion should

be done in practically all because we believed that the rather extensive laminectomy weakened the joint and necessitated this operation. As the technic was improved and less bone was removed from the laminae fusion no longer seemed necessary to repair the damage done by the operation itself and we began to omit it in selected cases where the lumbosacral joint appeared strong and where there was no accompanying backache. Elderly persons whose lives are less active also may obtain a satisfactory result without fusion in circumstances in which a younger person could not.

Our experience with this condition is comparatively recent and we are just beginning to accumulate statistical evidence which will aid us in deciding this question on a sounder basis. Already, however, we are beginning to see patients from whom a herniated nucleus pulposus has been removed without spine fusion in whom the involved disk has become thinner at the end of a year or more and who are complaining of backache. It is reasonable to expect that an intervertebral disk from which a large portion of the nucleus pulposus has been removed will collapse. Since the nucleus pulposus performs the function of a cushion and is the center of the action of motion of the two adjacent vertebrae it is to be expected that when it disappears the mechanics of movement of the vertebrae will be deranged and that a strain will be placed upon the lateral articulations. The natural consequence of this will be osteoarthritis. It may develop therefore that as a result of the experience obtained from the subsequent examinations of these patients we will advocate more rather than fewer spine fusions.

Spine Fusion Alone for Disk Herniation

On the other hand it frequently is asked whether spine fusion alone will relieve the symptoms from a disk herniation. This question is difficult to answer because very few if any spine fusions have been done without removal of the herniation when it was proved that one was present. It is argued that before the existence of this lesion was known many spine fusions were done in cases of sciatica and that many of them resulted in cure. It is assumed that herniation must have been present in a considerable number of them.

This may be true but it also is a fact that in many others so treated the sciatic pain persisted. An effort is being made to supply more definite information about these cases by carefully analyzing the end results in a large series. It seems sound policy at this time to advise that whenever a herniated nucleus is present it should be removed with or without the addition of a spine fusion.

Fasciotomy

Not long ago fasciotomy held the center of the stage as the newest procedure for the relief of sciatic pain. The reason for its effect was not definitely known but there is no doubt that it did give relief in many cases, sometimes apparently permanently. It is probable that some at least of these cases were herniated nuclei. Here again we must study these cases anew and attempt to determine more accurately in which cases this operation is indicated and how it produces its results.

WOUNDS OF THE THORAX

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and

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ANATOMIC AND PHYSIOLOGIC CONSIDERATIONS

Wounds of the thorax have the same fundamental characteristics as wounds elsewhere in the body, but the anatomy and physiology of the cardiorespiratory system introduce conditions which make these wounds unique and modify their treatment. For that reason it is advisable to commence this discussion with a brief review of this anatomy and physiology and the manner in which they affect the pathology of chest injuries.

The *thorax* contains the lungs with their pleural investment, the heart with its pericardium, the great vessels, the esophagus, the thoracic duct and the mediastinum. The thorax is a bony cage and its organs are separated from the abdominal organs by the *diaphragm*, which also acts as an important muscle of respiration. The *heart* and *lungs* (Fig. 113) are suspended in the thorax, the former by its vessels and the latter by the trachea. Normally they are adherent nowhere although they rest to a certain extent on the diaphragm. The *mediastinum* is the space between the lungs rather than a structure and is traversed in a longitudinal direction by the esophagus and aorta. Three important groups of *vessels* are found in the chest wall, viz. the intercostal vessels which course around the chest behind the lower margins of the ribs, the internal mammary vessels along the lateral margins of the sternum with which the intercostal vessels communicate and the *azygos* veins into which the intercostal veins drain posteriorly.

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and which enter the superior vena cava by hooking over the root of the right lung

The cardiorespiratory function can be roughly divided into the circulation of air and the circulation of blood. The *circulation of air* in the lungs is brought about by the chest bellows mechanism. During inspiration the pull of the chest muscles on the ribs and the contraction of the diaphragm increase the capacity of the thoracic cage. The lungs follow the chest

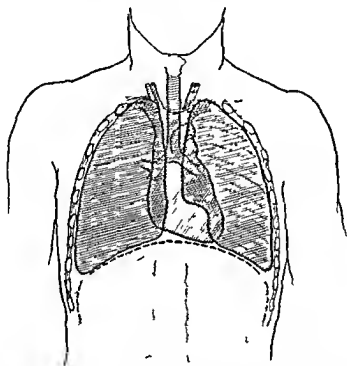


Fig. 113—Schematic representation of normal thorax. The heart is suspended by the great vessels and the lungs by the trachea and bronchi. Both rest on the diaphragm but are adherent nowhere. The mediastinum is in the midline. The pleural layers are held together by the cohesive force of the intrapleural negative pressure.

wall as a result of the cohesive force of the intrapleural negative pressure thereby drawing air into the pulmonary alveoli through the upper respiratory passages, the trachea and the bronchi. During expiration the muscles of respiration relax, the ribs drop in and the capacity of the thoracic cage decreases. Expiration may also be accomplished forcibly by muscular contraction. As the capacity of the thoracic cage decreases the elastic recoil of the lungs expels their air con-

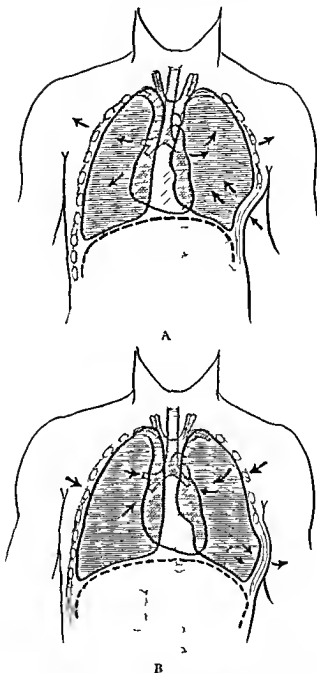


Fig. 114—Schematic representation of paradoxical respiration due to flail chest from multiple rib fractures. The lower left ribs are fractured producing instability of the chest wall in this area.

rent The intrapulmonary pressure therefore also varies with each phase of respiration being slightly negative during inspiration and positive during expiration Thus it is apparent that the circulation of air in the lung is a passive function normally dependent on among other things the negative pressure within the pleural space which permits the lungs to follow the chest wall

The *circulation of the blood* has two components, the pulmonary or lesser circulation motivated by the right heart and the systemic or greater circulation motivated by the left heart The blood enters the right heart from the venae cavae where the pressure is low and where the flow is greatly assisted by the suction action of the chest bellows mechanism i.e. the negative pressure phase of respiration It is then forced through the pulmonary circuit by the right ventricle and returned to the left heart From this point the left ventricle starts it through the peripheral circuit at a pressure six times greater than that in the pulmonary circuit In this connection it is well to remember that in the lung the pressure of the blood in the bronchial arteries is six times that in the pulmonary arteries although the volume of blood is much less

The gaseous exchange between environmental air and the tissues is therefore accomplished through two systems The respiratory system brings oxygen from the air to the blood in the alveolar capillaries and transports the carbon dioxide from the alveolar blood to the exterior The circulatory system carries the oxygen from the alveoli to the tissues of the body and transports the carbon dioxide from the tissues to the alveoli

It is thus apparent that the vital functions of the body depend on a delicate balance of forces among which the vari

A During inspiration the intact chest wall moves outward as indicated by the arrows expanding the lung beneath it which fills with air via the respiratory passages because of the negative intrapulmonary pressure so produced In the area where the ribs are broken the muscles of respiration cannot move the chest wall and the intrapulmonary negative pressure retracts this portion of the chest causing the air in the underlying lung to be expelled

B During expiration the procedure is reversed The contracting chest wall raises the intrapulmonary pressure which expels air from the lung under the intact ribs but causes the flail portion of the chest to bulge outward and its underlying lung to fill with air

ous pressures are essential components. Injuries to the chest can easily upset this balance as the following discussion demonstrates.

Anything which destroys the stability of the chest wall will cause the unstable portion to move according to the force of the intrathoracic pressure. Thus when the pull of the muscles on the intact ribs causes the chest to expand the unstable part of the chest wall will be pulled in by the negative intrathoracic pressure and on expiration the positive intra

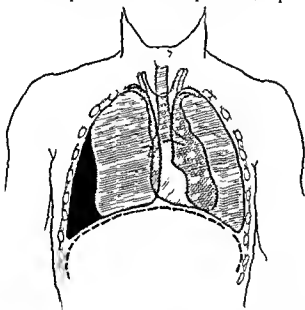


Fig. 115—Schematic representation of intrapleural collection of fluid. The collection of fluid in the right pleural space has produced a proportionate collapse of the right lung a height of the mediastinum directed to the left and a proportionate collapse of the left lung.

thoracic pressure will make the unstable portion bulge out. In other words the unstable portion moves in a direction opposite to that of the normal respiratory movement of the chest. This is *paradoxical respiration* (Fig. 114). Its effect is twofold. First it prevents the proper aeration of the lung underlying the flail portion of the chest and second the paradoxical movements embarrass respiration in the normal part of the chest.

An effusion of fluid, blood or air into the pleural space

the chest wall and underlying lung being intact will cause the lung on that side to collapse in proportion to the amount of effusion and as there is no normal rigid barrier between the two lungs this pressure will be transmitted to the other lung. Thus a shift of the heart and mediastinum will take place.

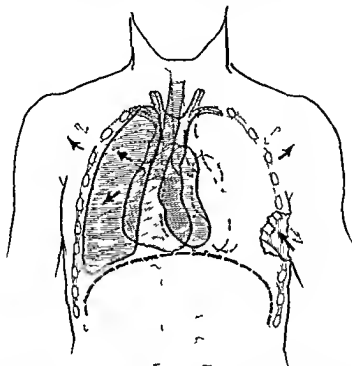


Fig 116—Schematic representation of mediastinal flutter. The solid lines indicate the chest in inspiration. There is a large gaping wound into the left pleural space permitting the entrance of air at atmospheric pressure and producing collapse of the left lung. During inspiration the right lung follows the chest wall because of its negative intrapleural pressure and is aerated to a certain extent but the difference between the negative intrapleural pressure on the right and the atmospheric intrapleural pressure on the left produces a shift of the mediastinum the heart and the left lung to the right. Solid arrows indicate the forces during inspiration. During expiration the forces are reversed as indicated by the broken line arrows and the positive pressure on the right swings the heart lungs and mediastinum to the left in the position indicated by the broken lines. Thus the mediastinum moves back and forth with the phases of respiration and the heart and lungs swing in a pendulum motion with it.

towards the good side with some collapse of the lung on that side. The thoracic contents will remain stable in their new positions except as the effusion increases (Fig 115).

If there is an opening through the chest wall into the pleural space the conditions are altered. With each inspiratory effort

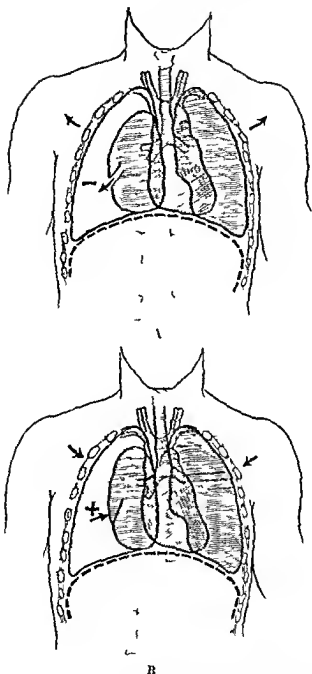


Fig. 117—Schriener's procedure for the treatment of tension pneumothorax. There is an oblique wedge of the right lung with a communicating piece of lung tissue which acts as a flap valve.

air is sucked into the pleural space and expelled during expiration thus causing a constant change of intrathoracic pressure and a shift of the thoracic contents with each phase of respiration a condition known as *mediastinal flutter* (Fig 116) If the diameter of the opening is smaller than the diameter of the trachea the underlying lung will collapse but is still capable of a certain amount of respiration and the mediastinal flutter will not be great If the diameter of the opening is larger than the diameter of the trachea the entire respiratory effort may be expended on drawing air into the pleural space and none will enter through the respiratory passages Aside from this respiratory difficulty the constant oscillations of the heart produce a severe cardiac embarrassment

If the chest wall is intact and there is an opening from the lung into the pleural space air will enter the pleural space and the lung will collapse as in other instances Usually the collapse will close the opening Should it remain open to permit a free flow of air mediastinal flutter will develop although such a condition is decidedly uncommon A not infrequent condition however, is a valved opening in the lung which permits the entrance of air into the pleural space but blocks its egress (Fig 117) Then respiration will build up a positive pressure and produce a shift of the mediastinum proportionate to the pressure The pressure will build up to the point where it is sufficient to close the opening a pressure usually enough to cause severe respiratory difficulty and circulatory embarrassment or even death This condition is known as *tension pneumothorax*

The pericardium is responsive to a certain amount of gradual stretching but is practically unyielding to a sudden increase of intrapericardial pressure For this reason a sudden influx of blood from a cardiac wound quickly builds up a

A During inspiration the negative pressure in the right pleural space causes the valve to open and air to enter from the lung

B During expiration the contracting chest wall produces a positive intrapleural pressure which acts to close the valve The air is trapped in the right pleural space and the positive pressure further collapses the right lung and causes a shift of the mediastinum and thoracic contents to the left With each inspiration the positive intrapleural pressure increases and quickly forces mediastinum heart and lungs over to the uninjured side compressing both lungs The drawing depicts the condition shortly after the start of the process before the shift is complete

pressure which approaches the pressure in the right heart. This reduces the cardiac output chiefly by decreasing the stroke volume first by preventing proper filling of the auricles and second by checking the amplitude of the ventricular pulsations. The clinical manifestations are a quiet heart upon auscultation and palpation, a low arterial pressure, a high venous pressure, engorgement of the neck veins, cyanosis and dyspnea. The heart rate is also slowed but this is probably due to vagus stimulation. The condition is known as *cardiac tamponade*.

With these physical and physiological concepts in mind consideration of chest wounds may be undertaken. Many classifications have been made and all have points to recommend them but for our purposes a classification according to the structures injured seems more appropriate than one according to the type of injury. It is important to remember that more than one structure may be injured by the same agent, that shock is an important concomitant in all chest injuries, and that there may be severe damage to the circulatory and respiratory systems. It is therefore necessary at the outset to combat shock, relieve pain, restore blood volume and provide oxygen. Treatment of the specific injuries may then be undertaken.

INJURIES TO THE CHEST WALL

Injuries to the chest wall consists of *contusions* and *fractures*. The treatment of simple fractures and contusions is too well understood to warrant further discussion. Occasionally, especially in young people, the chest may be compressed sufficiently to tear the lung without causing fracture of a rib or any considerable sign of external violence. This may produce a pneumothorax, a hemothorax or a subcutaneous emphysema. The treatment of these conditions will be discussed later.

Crushing injuries with multiple fractures of many ribs as well as other damage to the thoracic wall are of great importance and a high percentage of them prove to be fatal. Such injuries produce a flail chest with paradoxical respiration which so impairs the intake of air that dyspnea is a prominent symptom. This sets up a vicious cycle in which the

greater respiratory effort increases the paradoxical motion and this in turn further increases the respiratory embarrassment. The treatment is directed towards control of the paradoxical motion. If this is not great it can be accomplished by shot bags to the area or by strapping. In any severe case however this will be entirely inadequate. It will then be necessary to hold the ribs out by some form of traction working through towel clips applied to the ribs or wire sutures passed around the ribs. The former can be used as a temporary expedient until the latter can be rigged to a traction apparatus on the bed.

SMALL PENETRATING WOUNDS OF THE CHEST

Penetrating wounds of the chest caused by knife or bullet may have their chief effects in *hemorrhage* which may come from lung or chest wall. When the bleeding is from the lung the same injury also produces more or less pneumothorax and increases the pulmonary collapse already caused by blood in the pleural space. With the lower pressure in the pulmonary circuit or small peripheral bronchial arterioles the collapse of the lung will usually control the bleeding in a relatively short time. Should the signs of hemorrhage increase it is logical to suppose that there is damage to the internal mammary vessels, the intercostal vessels or the azygos veins. Hemorrhage from one of the great vessels is so rapidly fatal that it need not be considered. (Hemorrhage from wounds of the heart will be discussed later.) Hemorrhage from the mammary, intercostal or azygos vessels is always serious and frequently fatal. Treatment is directed towards stopping the bleeding and removing the blood from the pleural space. Blood in the pleural space is an irritant and the pleural reaction to this irritant plus the deposit of fibrin from the blood produces a dense fibrosis which will prevent subsequent re-expansion of the lung.

It is our opinion that when the bleeding has ceased removal of the blood becomes imperative but that it may be delayed some hours because clotting takes place slowly or not at all within the pleural space. Furthermore as the collapse of the lung has probably been an important factor in stopping the bleeding this collapse should be maintained for a

pressure which approaches the pressure in the right heart. This reduces the cardiac output chiefly by decreasing the stroke volume first by preventing proper filling of the auricles and second by checking the amplitude of the ventricular pulsations. The clinical manifestations are a quiet heart upon auscultation and palpation, a low arterial pressure, a high venous pressure, engorgement of the neck veins, cyanosis and dyspnea. The heart rate is also slowed but this is probably due to vagus stimulation. The condition is known as *cardiac tamponade*.

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is necessary. This is best accomplished by some form of closed drainage. The most simple is obtained by inserting a needle into the chest attaching a rubber tube to its outer end and placing the free end of the tube under water. An intercostal catheter may be used instead of the needle and likewise conducted under water. If the patient has to be transported a flapper tube is a very satisfactory appliance. This is an intercostal drainage tube whose outer end is covered with an open finger cot which acts as a flapper valve to permit the egress of air but to block its entrance. If the relief of the tension is not enough to restore the intrapleural balance and permit healing of the lung it may be necessary to suture the lung. A patient with an unrelieved tension pneumothorax should not be transported by air since the decreased pressure of the higher altitudes will increase the intrapleural tension.

LACERATIONS OF THE CHEST WALL AND LUNGS

In more extensive wounds such as might be caused by bomb fragments or the debris hurled by an explosion the situation is more complicated than in the small penetrating wounds which have been discussed. The opening of the thorax is of considerable size and produces a sucking wound with mediastinal flutter. In addition there is a contused laceration of the chest wall and probably a laceration of the underlying lung. This situation demands several types of treatment but the first and most important is to stop the mediastinal flutter by closing the sucking wound.

This may be accomplished by picking the wound if small by approximating the wound edges as much as possible and sealing by vaseline gauze or packing or by any other means that suggests itself at the time. It is essential to plug the opening immediately using whatever is at hand for the purpose without regard to sterility if need be and using sulfanilamide in the wound for prophylaxis. Then when an operating room and positive pressure anesthesia can be obtained the wound should be carefully debrided and all foreign bodies removed. Laceration of the lung should be sutured to prevent tension pneumothorax and hemorrhage. In some instances the damage to the lung will be so great (as in wounds from large fragments or in crushing injuries) that the source of the bleeding

is not immediately apparent. Under such conditions a catheter or rubber tube can be applied as a tourniquet around the pedicle of the injured lobe and the bleeding controlled by this means until it is permanently controlled by suture or ligation. In some instances it may be necessary to remove the lobe or even the lung but these are rare. Before resorting to this for bleeding it is well to remember that a piece of muscle sutured over the bleeding point as a free graft acts as a very efficient hemostatic agent.

After the intrapulmonary condition has been controlled and the wound debrided the chest should be closed. This may be difficult if there is much loss of substance. The rib above and the rib below may be drawn together by sutures placed around them and then the muscle and skin closed over them. If the defect is too great the lung itself may be sutured into it and the wound closed by an occlusive dressing of vaseline gauze.

Drainage is a matter of individual choice. If the contamination is not great 8 or 10 gm. of sulfanilamide may be put into the wound and no drainage used. It is our preference to drain any wound with more than a minimal contamination by means of closed drainage through an intercostal stab wound. In the subsequent course it must be remembered that intrapleural fluid or pus may develop which must then be treated as indicated.

TRAUMATIC EMPHYSEMA

Subcutaneous emphysema is occasionally associated with lung injuries. External injuries cannot always be demonstrated in these cases especially in children whose resilient thoracic cage may allow enough pressure to damage the underlying lung without rib fracture or visible laceration. Usually the injury can be determined however and it is commonly a laceration of the lung accompanying a rib fracture. The subcutaneous emphysema starts in the vicinity of this injury and may spread all over the body although the fascial attachments to the mandible and inguinal ligaments may stop its spread at these points. Uncomplicated subcutaneous emphysema will usually take care of itself without treatment but should it involve loose cellular tissue as in the scrotum for

instance there may be a considerable and uncomfortable distention. This can readily be relieved by multiple skin punctures with the point of a scalpel thus releasing the air. Of course strict aseptic precautions should be observed with the procedure.

Mediastinal emphysema presents a much more serious situation. It is most often the result of injury to the trachea or larger bronchi and has a mechanism similar to that of tension pneumothorax. More rarely it is produced by a rupture of the lung under an intact visceral pleura like the subperiosteal

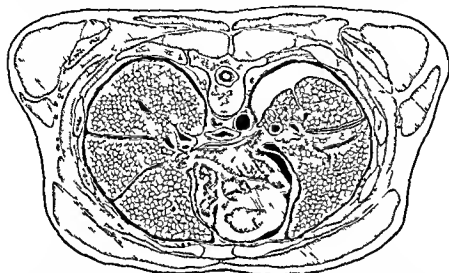


Fig. 118—Production of mediastinal emphysema from subpleural rupture of lung. The lung has ruptured beneath an intact visceral pleura producing an air pocket between lung and pleura. The air dissects its way towards the hilum where the visceral pleura is reflected to form the mediastinal pleura. The drawing depicts the air about to break through into the mediastinum.

fracture of a bone. The air collecting under the pleura may dissect its way to the hilum where the visceral pleura is reflected to form the mediastinal pleura and escape into the mediastinum (Fig. 118). Mediastinal emphysema is characterized by cyanosis and dyspnea due to the pressure on the heart and great vessels especially the vena cava. Subcutaneous emphysema appears in the suprasternal notch and spreads from there so that it is equally bilateral from its first appearance unlike the ordinary subcutaneous emphysema which spreads from the site of the injury. Auscultation over the sternum

will reveal a crackling sound synchronous with the heart beat and without relation to respiration. Prompt relief may be necessary and can be obtained by incising the skin and platysma in the suprasternal notch and plunging the finger down into the mediastinum thus giving vent to the accumulating air.

TRAUMATIC ASPHYXIA

Cyanosis without dyspnea is found in the rather unusual condition known as traumatic asphyxia. This is characterized by a sharply defined area of cyanosis of head and neck, sometimes extending down onto the chest or even lower. It is the result of a sudden compression of the chest which forces the blood back out of the venae cavae. The blue color may be very intense and associated with what appears to be subconjunctival hemorrhage. Asphyxia has nothing to do with the situation which is due solely to a stagnation of blood in the superficial veins. Of itself the condition is not serious and will disappear in three or four days without treatment.

BLAST INJURIES

Bomb explosions also produce injuries to the lungs without external evidence of trauma. These are known as blast injuries and are not in the same category as injuries caused by solid objects hurled by the force of the bomb explosion. This type of injury has already been discussed. To properly understand the pathology of blast injuries the physical properties of a high explosive detonation should be considered.

An explosion is the sudden release of gases produced by the decomposition of an unstable solid and is characterized by a high pressure wave of short duration (0.006 second) and great velocity (several miles per second) followed by a longer wave of negative pressure (0.03 second). The intensity of the pressure wave varies with the violence of the explosion and has been measured to be as much as 200 atmospheres (133 tons per square inch). The suction wave can never be more than 15 pounds per square inch because that is a perfect vacuum. The pressure is highest at the explosion and decreases with great rapidity as the distance from the explosion increases.

The effect on the body is chiefly on the lungs. The force of the wave disrupts the alveolar capillaries and ruptures the alveolar walls. The lungs contain various amounts of extravasated blood and the bleeding has been known to continue for more than four days. The chest wall and other parts of the body may appear unharmed and the only evidence of injury may be a bloody frothy sputum.

Clinically, the patients are in profound shock. Dyspnea, air hunger and cyanosis are usually present and the victims cough and raise frothy blood stained sputum. Abdominal signs are not uncommon and there may be sufficient pain, rigidity and distention to suggest an acute abdominal catastrophe. Most of the cases with this diagnosis in which operation is done prove to have no abdominal lesion. Moreover the use of an inhalation anesthesia in the presence of pulmonary bleeding may prove fatal. Neurological signs are not infrequent.

While this symptom complex usually appears soon after the injury the bleeding may be slow and not produce symptoms for several days. If the patient survives the lung signs may later be those of complete consolidation.

Adequate air raid shelters produce protection against blast injuries but for those forced to be out of shelter a vest of sponge rubber forms some barrier to the force of the blast. A prone position on the ground is better than a supine position as the back affords more protection than the front of the chest.

The *active treatment* consists in absolute rest and oxygen. Until the bleeding stops and the blood is absorbed the damaged lungs should be given as little to do as possible. Shock should be treated but opiates should be used only in the smallest doses necessary to control pain since they act as respiratory depressants. Oxygen can be administered in an oxygen tent by means of a B.L.B. mask or through a nasal catheter if no other means is available. Great care should be exercised to prevent any unnecessary treatment or activity and the use of a general anesthetic should be reserved for the utmost urgency.

INJURIES TO THE HEART

Injuries to the heart are usually immediately fatal and do not come to the attention of the surgeon. If they are not

promptly lethal measures may be instituted to relieve the condition and preserve life

Contusions of the heart are more frequent than suspected and may consist of traumatic pericarditis myocarditis or even myocardial laceration. The chief signs are arrhythmias, decreased cardiac output and rarely cardiac tamponade. Among the arrhythmias ventricular fibrillation is usually promptly fatal but auricular fibrillation frequently responds to treatment. The other arrhythmias are of less severity. In this connection it is well to emphasize that a slow pulse can be due to vagus stimulation which may mask a serious underlying condition not apparent until the vagus irritability wears off.

The *treatment* is rest in all conditions and the use of the various cardiac drugs is indicated. In fibrillation quinidine is indicated but its results are frequently disappointing which unfortunately is true of most of the other cardiac drugs. Cardiac tamponade unless serious had best be left alone or treated by aspiration. If serious it should be treated as described below under puncture wounds of the heart. The symptoms may last from hours to years and may not become apparent until years after the injury when initiated by the resulting scar.

Lacerations of the heart by knife or bullet have recently received considerable attention and not a few have been successfully sutured. The symptoms of cardiac tamponade developing after such a wound indicate prompt attention. Occasionally the bleeding may be slight and cease before the tamponade can become serious. In such cases aspiration can be undertaken but not until several hours have elapsed and there is no longer danger of starting up the bleeding again by decompression. In most instances aspiration should not be done except partially slowly and as a temporary procedure while preparing for operation.

The operation consists in resecting the left fourth, fifth and sixth costal cartilages through a curved longitudinal incision. This exposes the uncovered space of the pericardium which can be then incised and the blood evacuated. The bleeding laceration is quickly plugged with the finger until three stay sutures can be inserted—one at the apex of the

heart and one at each end of the laceration. While the heart is steadied by these stay sutures the wound is quickly closed with interrupted sutures of silk the stay sutures removed and the incision closed except for an opening between pericardium and left pleural space to provide drainage to prevent reformation of the tamponade.

ABDOMINOTHORACIC INJURIES

In many instances thoracic injury is associated with abdominal injury usually accompanied by a tear of the diaphragm. In the presence of a combined injury of this sort the surgeon will have to exercise his judgment in deciding which to attack first but for the most part the thoracic injury should receive precedence since the time factor is usually more important for thoracic wounds of this magnitude than for abdominal wounds.

With the chest open the diaphragmatic wound can be located and inspected. It should not be sutured at once but should be enlarged to permit exploration of the abdominal contents in its vicinity. When the extent of the abdominal injury has been ascertained it is repaired if possible. Otherwise the diaphragm is sutured the chest injury treated and then the abdomen is opened and the damage repaired. In suturing the diaphragm its motion will usually not bother the surgeon but should it be desirable to quiet it this can be accomplished by injecting procaine into the phrenic nerve as it courses along the pericardium. In the presence of any considerable lung injury especially if infection is anticipated paralysis of the diaphragm for more than a few hours is inadvisable as a paralyzed diaphragm makes an ineffectual cough.

ESOPHAGEAL AND THORACIC DUCT INJURIES

Injury to the esophagus as a result of external violence is decidedly uncommon. Should it happen the occurrence of a fulminating mediastinitis is almost certain. Because of this the chest should be opened at once the laceration sutured sulfanilamide put into the wound and the chest closed with drainage of the mediastinum.

Laceration of the thoracic duct is even more rare. It is

manifest by the appearance of large quantities of chyle in the pleura. Repair of the laceration or ligation of the cut ends can be attempted through a thoracic incision but not much can be expected of it.

LATE TREATMENT AND COMPLICATIONS

In the foregoing no attempt has been made to discuss the late treatment and complications of thoracic wounds. These are highly important but lack of space will not permit their discussion. In general it can be stated that infection must be treated, oxygen administered and supportive measures employed as in the surgical treatment of other thoracic diseases. These cases may be so long drawn out that they test the patience and courage of surgeon and victim alike but a large number can be brought to a successful conclusion.

SUMMARY

1. An understanding of the physics and physiology of the thorax and its contents is essential for the proper treatment of thoracic wounds.

2. The simplest procedure should be employed which will meet the requirements of the pathological physiology.

3. If simple methods are not adequate the surgeon should not hesitate to use radical procedures.

4. All procedures should be based on accepted surgical principles.

REPAIR OF LACERATED NERVES AT THE WRIST

H O SONNENSCHN EIN M D

ALTHOUGH our knowledge of wound healing infection and careful atraumatic surgery is increasing and we are better equipped than formerly to understand and evaluate surgical problems as we are confronted by them the results of peripheral nerve surgery are none too gratifying and laceration of a nerve trunk leads to severe disability

In spite of all these well known facts lacerations of the finger or wrist particularly when first seen in the emergency room of a hospital are treated by closing the wound by a simple stitch of the skin and a nerve or tendon injury is not even considered If the wound appears formidable because of the depth of the laceration or if a lacerated tendon or nerve stump is seen in the wound the patient is admitted and a junior surgeon is summoned to perform an operation requiring delicate atraumatic technic an intimate knowledge of anatomy plus complete understanding of tissue resistance and repair aside from infinite patience at the operating table

In war wounds caused by high explosives and shell fragments may occur in any part of the body and they are usually so large that all tissues involved are destroyed In industry chiefly the exposed parts are injured The wrists and hands suffer most frequently by cutting with sharp instruments of metal or glass followed in frequency by injuries to the ankles or feet But whatever the extremity that is cut there is inevitably a laceration of a nerve and of one or more tendons and their sheaths Small puncture wounds likewise may cause laceration of a single nerve notably the median nerve at the wrist and the radial nerve in the arm The peroneal nerve in the leg is occasionally severed by a small almost undetected puncture wound

An altercation takes place during which a knife is wielded and in attempting to protect himself the victim is cut across

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the flexor surface of the wrist dividing all structures that happen to be in the way of the weapon. Bullets fired from a pistol rifle or machine gun may completely or partially divide the nerve trunk or simply contuse it.

Diagnosis of Nerve Injury in Wounds of the Extremities

Injury to a nerve should be suspected in any wound of the extremities. If the possibility of nerve injury is borne in mind diagnosis is simple and if the surgeon is thoroughly familiar with the anatomy of the part which he should be diagnosis of what nerve is involved and at what level should not be difficult.

If the nerve is completely severed whether the ends are frayed, crushed or cleanly cut across the loss of motor or sensory function or both is complete. Occasionally these same symptoms may be caused by severe compression or contusion in which case sometimes they are of temporary nature. Partial division of a nerve may cause some damage and may frequently lead to a confusing clinical picture. Whenever in such a situation there is any doubt as to the exact nature of the injury a thorough investigation of the nerve trunk must be performed. Finally it must be remembered that a small puncture wound may cover up considerable subcutaneous damage.

Emergency Measures

When the patient is first seen either at the place of injury at a first aid station or in the emergency room of the receiving hospital hemorrhage if present must be controlled by ligature, suture or packing. A tourniquet may be applied while controlling the hemorrhage by ligature or packing. Tetanus antitoxin should also be given and the injured part placed in an emergency splint after having been covered with sterile dressings. It is of course essential to watch the tourniquet closely and to make sure that it is and remains well placed and that it will not be left on too long. It does not have to be removed if the operation is to be done immediately.

If one suspects the danger of gas bacillus infection because of the locality where the wound was received or by the presence in the wound of a certain type of foreign matter

appropriate serum can be given. Likewise it is evident that if there has been considerable loss of blood the patient should be given a transfusion. Shock if present must also be combated.

Unless contraindicated by shock, severe avulsions, extensive fractures or unless the limb is in danger, repair is indicated as soon as possible.

Anesthesia Hemostasis

Local anesthesia has no place in this type of surgery. Brachial block in the upper extremity is becoming more and more popular and can be used by those who are familiar with its technic. It requires some experience. To obtain a sufficient degree of anesthesia with this method however may require from one half to one hour and this delay superimposed upon other delays inherent in the situation violates the safety time limit for primary repair.

General anesthesia should be employed. Besides always being available it can be administered quickly and except for a hypodermic injection of morphine and atropine needs no special preparation. Gas oxygen or cyclopropane are the most widely used.

Hemostasis is absolutely essential. A dry field is necessary for proper identification of the structures. This is best obtained by the use of tourniquet which may be an elastic one or the cuff of a blood pressure apparatus. The use of the tourniquet avoids the additional trauma caused by wiping with sponges and makes clamps and packing in the field unnecessary. It adds materially to the speeding up of the whole procedure.

Cleansing the Wound

The wound should be thoroughly cleansed using a neutral sterile soap or tincture of green soap. Gauze wipes should be used. A brush causes too much trauma and oozing. Gentleness is the watchword. Pour ether into the wound. Gently lift the edges of the wound with retractors so that the solution and ether can come in contact with all parts of the involved area. If there has been soiling with grease as in industrial or machine accidents the soft parts are given a preliminary

cleansing with benzene. This program must include the adjacent skin far and wide and as much care and attention should be given to this procedure as to the technical operative detail.

Use soap, water and ether freely. A minimum of ten minutes must be allowed for this cleansing. The parts are dried by patting with sterile towels after which the area is painted with tincture of iodine. A moderate amount of iodine is also poured into the wound. Any other preparation customarily used as a substitute for iodine provided it is not irritating may be employed such as merphen or picric acid.

Time Limit for Primary Repair

Primary union can be obtained in most wounds if they are seen early and treated in this way. No attempt to repair a wound is to be made if it is obviously or potentially infected. To make the decision requires experience and familiarity with this type of wound. The average clean cut laceration without any crushing or loss of substance can be safely sutured within six hours after the initial trauma. In the case of a crushing wound or one due to an explosive type of force containing much foreign material and requiring extensive debridement it is perhaps wiser to apply sulfanilamide powder and wait. As we become more familiar with the use of the sulfa products and certainly with the experience to be gained during the present war we may and unquestionably will be able to postpone the nerve suturing to perhaps twenty-four or thirty-six hours after the preliminary procedure and then be reasonably sure that the wound will remain clean. However, no drug can take the place of good surgical judgment.

Debridement of the Wound

All devitalized tissue must be removed. This excision must be thorough and complete. It should be persisted in until normal tissue is visible as seen by color and bleeding. All crushed muscle tissue must also be removed. The skin edges must be freshened. It is obvious that no foreign material should remain in the wound. This debridement must be performed carefully and gently.

Finding and Identifying the Nerve Ends

The wound is closely inspected and if the nerve ends can be isolated in the original wound this should be decided upon quickly. Further trauma to the wound and nerves must be avoided by searching for the severed ends. If they are not immediately seen gentle movement and instrumental retraction flexing or extending the part may be of help but in order to avoid a further loss of time the original wound should be enlarged. This can be done by extending the ends of the laceration or by an additional incision that bisects the original wound. A wide exposure of the field will cause considerably less trauma and will make identification of the structures much easier than will any attempt to fish out the stumps with sharp instruments introduced beneath the edge of the original skin edges.

When the ends have been isolated sutures should be employed immediately. Place a small suture in each corresponding proximal and distal stump away from the cut ends to use as guides and to prevent rotation. This suture is placed in the nerve sheath and is removed before closing the wound. The isolated ends are sutured and these sutures can be used for mild traction while the other stumps are isolated and the sutures placed. When sure that all have been identified matching of the cut ends is done. These are tied only when one is ready to close the wound. By postponing the actual tying of the sutures until all have been identified one can better satisfy himself that all damaged structures have been isolated. This will avoid useless untying and retying. The common error of repeatedly picking up nerve ends with forceps as a means of identification should be avoided. The field should be moistened from time to time with saline to avoid drying. Use a safety razor blade to section the nerve back until healthy fibers are seen. It causes less trauma than scissors.

Types of Suture and Suture Material

The choice of the type of suture and of suture material must rest with the operator and his experience. Both absorbable and nonabsorbable material have been used with success. The main object is to hold the cut ends in apposition without strain pull or tension until healing has taken place.

Cohesive substances made with acacia as a base have been mentioned as substitutes for suture material and although there has been no wide clinical use of them if one is experienced with them and one is at hand it removes the necessity of suturing and whatever trauma the suture produces in the nerve tissue.

A glue made with blood plasma has been used in experimental surgery on animals with satisfactory results but no clinical reports are available as yet.

Fine silk has sufficient tensile strength to maintain apposition which is all we desire. Grades of silk vary with the different manufacturers and I use grade A which is very fine in texture and at the same time sufficiently strong so that it does not break easily. The numbered grades of silk are too thick. It is wise to look at the silk before operation and if the finer sizes are not available one can unstrand some of the larger sizes and use a single strand. Silk has the advantage of holding in the presence of infection. Moreover if there is some slipping or distraction of the suture line silk sutures will identify the structures if a second operation becomes necessary.

The *needles* must be small, sharp and atraumatic. Smaller needles are used for the smaller trunks, somewhat larger for the better sized nerves. Straight needles flattened on both sides are best. Intestinal needles offer all the advantages for this type of work and can be used.

There are many types of sutures described to bring the severed nerve ends together and hold them (see Fig. 119). They all attempt to do this without allowing any dead space between the ends. It is this space that will defeat the most carefully prepared and performed surgical procedure. There are two main types of sutures. Apposition sutures may be those that are introduced through the nerve sheath and the other through which apposition is obtained by passing the suture covering the nerve tissue itself. Suture of the nerve covering is done by multiple fine stitches or by laterally placed locking types. Many are described.

There is no one suture that will completely or accurately appose the nerve ends. It has been the writer's experience that although some trauma is caused by the fine silk suture when it is passed between the nerve fibers a better apposition

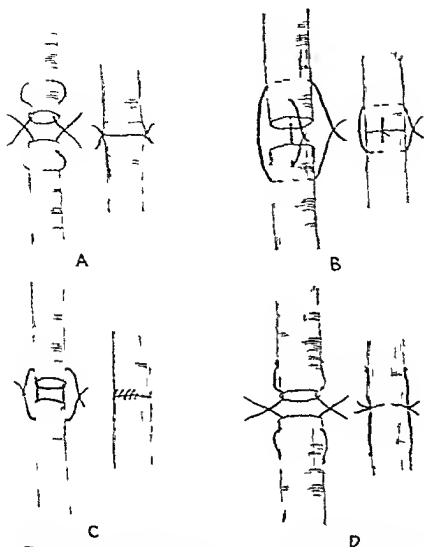


Fig 119-4 Modified Bunnell suture. One needle is passed transversely through the axis. The second needle is passed as the first in the long axis of the nerve. When tied the suture leaves a slight mushrooming effect.

B French suture. One suture passes transversely through both ends of the nerve. A second suture is passed parallel to the long axis and tied, serving as reinforcement of the first suture.

C Suture placed through the neurilemma all around the circumference of the nerve.

D A suture is passed through the neurilemma at a distance of about 1 cm from the cut surface. There it is anchored by a knot and then brought back through the neurilemma, creating a loop. When tied, tension between the approximated trunk is created and good apposition is obtained.

is obtained by means of this type of suture than by simply suturing the nerve sheath itself. Several types can be used

Cohesive substances made with acacia as mentioned as substitutes for suture mater there has been no wide clinical use of them except with them and one is at hand it removes suturing and whatever trauma the suture nerve tissue

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The *needles* must be small, sharp and atraumatic. Needles are used for the smaller trunks, somewhat the better sized nerves. Straight needles flattened at the ends are best. Intestinal needles offer all the advantages for this type of work and can be used.

There are many types of sutures described to suture severed nerve ends together and hold them (see Appendix). They all attempt to do this without allowing any space between the ends. It is this space that will defeat the purpose.

Two main types of sutures. Apposition suture and covering suture. Apposition sutures are those that are introduced through the nerve sheath and apposition is obtained by passing a suture through the nerve tissue itself. Suture of covering is done by multiple fine stitches or by placing locking types. Many are described.

There is no one suture that will completely or accurately appose the nerve ends. It has been the writer's experience that although some trauma is caused by the fine silk when it is passed between the nerve fibers a better apposition is obtained than by any other method.

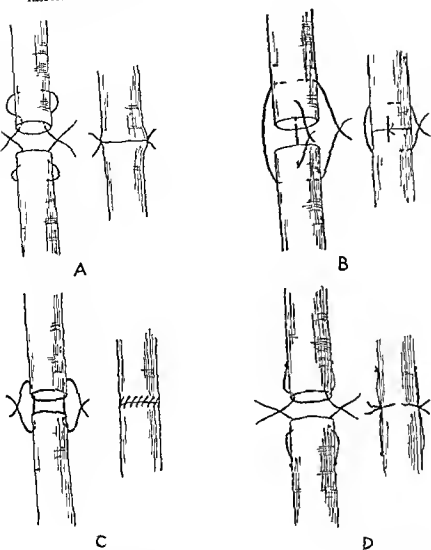


Fig 119—*A* Modified Bunnell suture One needle is passed transversely and then into the axis The second needle is passed as the first in the long axis of the nerve When tied the suture leaves a slight mushrooming effect

B Friedreich suture One suture passes transversely through both ends and is tied A second suture is passed parallel to the long axis and tied serving as reinforcement of the first suture

C Suture placed through the neurilemma all around the circumference of the nerve

D A suture is passed through the neurilemma at a distance of about $\frac{1}{4}$ inch from the cut surface Here it is anchored by a knot and then led towards the severed end where it is passed again through the neurilemma forming a loop When tied tension between the approximated trunk surfaces is avoided and good apposition is obtained

is obtained by means of this type of suture than by simply suturing the nerve sheath itself Several types can be used

There is the type in which two sutures pass through the nerve at right angles to each other and a suture parallel to the nerve which emerges just beneath the neurolemma at the ends a mushroom effect being obtained in tying. Irrespective of the type of suture used a few small stitches through the sheath of each segment will bring about satisfactory end to end closure if satisfactory apposition as determined by inspection was obtained.

Technical Considerations

Avoid tension. If necessary flexion or extension of the proximal articulation will often afford sufficient length to appose the ends properly. The practice of covering the sutured ends with fat fascia vein or any other material has been thoroughly discarded.

Cosmetic closure of the wound should not be attempted. Simple interrupted stitches of silk are sufficient to coaptate the skin. The injured part is then splinted in a position of rest and elevation. Depending upon the type of nerve involved all necessary aids of physical therapy such as sinusoidal stimulation massage and active and passive motion should be employed to hasten convalescence.

Not all operating rooms are equipped with the ideal instruments and sutures for this type of work. A little time spent before commencing to select the smallest hemostats forceps retractors and so forth will be of great benefit. Since this procedure is time consuming all these minor details should be attended to in the preoperative stage. Annoyance and loss of time will be avoided and a satisfactory result is more assured. Nevertheless the operative procedure however well prepared and executed is always a lengthy one. An operating time of from two to three hours is rather the rule than the exception. The surgeon and the assistants will find it of great help to use stools and sit down comfortably right from the start.

Secondary Repair

Sensory portions of the nerve regenerate sooner than the motor fibers. Regeneration proceeds more rapidly in the purely motor and sensory type than in the mixed type. Cer

tain nerves seem to regenerate better than others. The radial nerve seems to repair well. The ulnar nerve has given the most trouble. The time at which secondary repair should be undertaken is very difficult to determine if infection has complicated the original procedure. Certainly if no progress has been made at the end of three months one can hardly expect further improvement without secondary repair. Likewise if after the condition shows improvement there comes a time when all improvement ceases and the condition remains stationary for several months then one is justified in advising secondary exploration. Unfortunately, however, even if all conditions of repair are favorable and a satisfactory surgical procedure has been performed repair and restoration of function do not always occur.

Functional Results

When examining for the return of function one must be very guarded in evaluating the early findings. Although the anatomic distribution of sensory nerves appears well established considerable overlap is encountered. This is especially true in regard to the distribution of the median and ulnar nerves on the volar aspect of the hand and fingers where one rather frequently finds considerable variation from the description of those nerves given customarily in textbooks.

If only a nerve is involved and this has been satisfactorily repaired motion of the part can be commenced at the end of three weeks. At this time the scar is firm enough to withstand any undue stretching or strain. Inasmuch as this injury is almost invariably complicated by division of tendons, tendon sheaths and blood vessels the time at which to start active motion will depend largely upon the latter factor.

Since the division of a single nerve trunk by trauma is the unusual result of an accident the first difficulty and the most important factor mitigating against the successful result of a well planned and well executed repair is the involvement of adjacent structures. One or more of all the tendons or sheaths may be damaged and require suturing, adding the proper tendon repair to the surgical procedure on the nerve or nerves. In the crushing or explosive type of wound there may be considerable loss of tissue. This type of wound is

usually potentially infected and if one decides that it is primary repair cannot safely be attempted.

In spite of the fact that secondary repairs are more difficult, more uncertain and may have to be performed in several stages following preliminary excision of scar tissue and the utilization of skin grafts if any doubt or question arises as to the question of infection it is wiser and safer to leave the wound open and treat it as an infected wound after the preliminary cleansing and debridement.

SUMMARY

The repair of lacerated nerves of the wrist and fingers is usually a part of a general laceration of all anatomical structures. Immediate repair depends upon the time element, type of wound and the possibility of determining whether the wound is potentially infected. Proper diagnosis based upon a knowledge of anatomy and the skill required for careful atraumatic handling of tissues. It is far better if there is any doubt that repair of the nerve not be attempted. Secondary operation can then be done at some future time with better prospect for a favorable result.

The advanced theaters of battle scarcely offer the opportunity for operating in these cases. Following emergency treatment including measures for combating shock and controlling hemorrhage and the installation of sulfanilamide in the wound the patient can be transported back to a base hospital equipped for such work. The greatest handicap is a complicating infection. As the early use of a sulfa drug now largely avoids the danger of infection we can now delay surgery and still hope for better results than were obtained in the last war. We can also apply these methods to our civilian and industrial patients and so overcome the unsatisfactory results from this class of trauma which results in severe disabilities and great economic loss.

INJURIES OF THE KNEE JOINT

IRVIN BALENSWEIG MD FACS

ETIOLOGY SYMPTOMS AND TREATMENT

TRAUMATIC SYNOVITIS

ETIOLOGY—A sprain or twist a sprain of the external lateral ligament is rare

SYMPTOMS—Pain general at first and then localized to the inner side of the knee in the neighborhood of the internal lateral ligament swelling loss of normal joint markings and limp The patient feels more comfortable when walking with the knees flexed

TREATMENT—If the effusion results in a tenseness aspirate on the outer side just above the level of the patella Strap and renew strapping every four days Teach quadriceps exercises Immediate weight bearing using a cane on the opposite side

Use ice bags intermittently for relief of pain Heat should not be used during acute phase of injuries since it increases congestion and pain

Posterior plaster splint may be employed for patients with a low threshold of pain

PROGNOSIS—Recovery in two or three weeks

RECURRENT SYNOVITIS

ETIOLOGY—Suspect internal derangement It may occur as a result of quadriceps insufficiency that is quadriceps weakness following lack of proper exercises following an acute synovitis *Tuberculosis and lues should be ruled out* Tuberculosis may occur in its synovial form in adults without bone involvement and simulate chronic recurrent synovitis Luetic synovitis can follow a traumatism Both the blood and synovial fluid serology aid in the early diagnosis X rays are negative and such joints act like any other traumatic

joint lesion. In later stages however the pain becomes quiescent but the joint becomes disorganized allowing abnormal mobility. The x rays now disclose joint irregularities with aberrant bony deposits. Occasionally one observes idiopathic recurrent synovitis without being able to ascertain its cause even though a mild trauma may have been the initiating factor.

TREATMENT—When internal derangement is suspected arthrotomy is indicated.

If tuberculosis is proved by laboratory findings a knee fusion is far superior to a synovectomy.

The treatment of the comparatively early case of luetic synovitis following trauma is antisyphilitic medication and immobilization of the affected knee. In the later stages joint fusion by means of massive bone grafts may suffice. Where such therapy does not result in a stable joint then amputation may be resorted to.

The usual care of idiopathic recurrent synovitis is that of repeated aspiration temporary immobilization physical therapy quadriceps exercises and lastly synovectomy. Synovectomy is to be seriously considered in all late cases (one to three years following onset).

TRAUMATIC HEMARTHROSIS

ETIOLOGY—Traumatic hemarthrosis may be due to a synovial laceration adjacent to the attachment of the semilunar cartilages to a fracture at the base of the spines of the tibia or more rarely to a fracture of the articulating surface of the patella.

SYMPTOMS—Swelling with joint tenseness local heat moderate to severe pain flexion deformity of knee limitation of motion and occasional elevation of body temperature.

TREATMENT—*Hemarthrosis due to synovial laceration*. Aspiration using a large bore needle or trocar. Application of pressure bandage and posterior molded plaster splint. Intermittent application of ice bags. The use of crutches without weight bearing for about one week. Quadriceps exercises after the fourth day. Discontinue rigid immobilization after seventh day then resort to adhesive strapping and elastic bandage. Physical therapy is begun two weeks after onset.

Hemarthrosis due to fracture of articulating surface of patella Arthrotomy with removal of loose fragment and evacuation of blood and blood clots Immobilization for forty eight hours Quadriceps exercises Patient ambulatory after fourth postoperative day, using crutches for two weeks Physical therapy

Hemophilic arthritis Measures to improve clotting time of blood Aspiration Pressure bandage Quadriceps exercises after two weeks Ambulatory after four weeks No heat or massage

PROGNOSIS —Excellent for complete return of function unless complicated by hemophilia A hemophilic arthritis is progressive in character

INJURY OF THE LATERAL LIGAMENTS

ETIOLOGY —An abduction strain of the extended knee results in a partial or complete disruption of the internal lateral ligament either from its tibial or more likely its femoral attachment

SYMPTOMS —Pain local tenderness at site of injury swelling thickening of tissue at site of injury limitation of flexion and more particularly of extension and abnormal lateral instability The last named condition is best diagnosed by injecting novocain following aspiration of the excess synovial fluid then taking anteroposterior x rays with the knee in the neutral position and with the lower leg forcibly abducted at the knee By this means a widening of the inner portion of the joint is readily detected

Complications Displacement of medial meniscus either alongside the internal femoral condyle or laterally into the joint

Calcification of the internal lateral ligament (Pellegrini Stieda's disease) This is identified roentgenologically within two to three weeks following the injury as a small cap of bone adjacent to the upper limit of the internal femoral condyle In a few cases the greater part of the medial lateral ligament may be involved The clinical characteristics of this complication are the persistence of local pain and tenderness aggravated by motion or physical therapy

TREATMENT—*Care of the simple case* Aspiration of the tense joint Pressure bandage without weight bearing for four days Application of plaster encasement from ankle to groin Daily quadriceps exercise Elevation of inner border of shoe by $\frac{1}{4}$ inch when ambulatory Removal of encasement after four weeks Physical therapy

Care of the complicated case Should lateral instability persist after four months of good conservative care one should consider the advisability of operatively reinforcing the avulsed ligament

If Pellegrini Stieda's disease occurs causing mechanical interference due to its extensiveness the internal lateral ligament can be safely excised after the elapse of fully six months following its recognition

INJURIES OF THE CRUCIAL LIGAMENTS

ETIOLOGY—The anterior crucial ligament is attached distally to the anterior portion of the tibial spine thence courses upwards outward and backward to become attached to the medial aspect of the external femoral condyle When avulsed it allows of abnormal forward mobility of the tibia on the femur

The posterior crucial ligament arises behind the tibial spine and courses upwards medially and anteriorly inserting into the lateral side of the internal femoral condyle When avulsed it allows of abnormal posterior mobility of the tibia on the femur

SYMPTOMS—Pain swelling abnormal anterior or posterior mobility of the tibia on the femur and disability

TREATMENT—Plaster immobilization for two to four months Daily quadriceps exercise Physical therapy Conservative measures usually suffice Occasionally following complete avulsion of both cruciate ligaments with marked persistent instability and disability the surgeon is called upon to reconstruct these ligaments

PROGNOSIS—Care and prognosis depend upon the extent of the instability The end results when there has been complete avulsion of both cruciate ligaments are far from satisfactory in laborers

FRACTURE OF THE TIBIAL SPINE

ETIOLOGY—Fracture of the tibial spine is an avulsion of the anterior crucial ligament with a fragment of bone from its tibial attachment. It is caused by a blow that drives the femur backward while the knee is flexed.

SYMPTOMS—Pain, hemarthrosis, abnormal forward mobility of the tibia on the femur, limitation of extension due to mechanical bone block, and x-ray findings indicating line of fracture.

TREATMENT—Immobilization in complete extension for six weeks. Should the loose bone fragment cause mechanical impediment after a conservative attempt at reduction, it should be excised. Quadriceps exercise. Use of temporary support following removal of plaster for four to six weeks.

PROGNOSIS—Satisfactory.

DISLOCATION OF KNEE JOINT

ETIOLOGY—Dislocation of a knee joint is a rare condition occurring in three varieties. The most frequent variety is the anterior type in which the tibia is displaced in front of the femur; the second form is that in which the tibia is found in back of the femur; and the rarest kind of all is complete lateral disruption of the capsular structure together with the cruciate ligaments.

SYMPTOMS—Extreme pain, deformity, hemarthrosis with tenseness, disability, and circulatory interference.

Complications—Injury to popliteal vessels and nerve in joints.

TREATMENT—Reduction under anesthesia using traction. Immobilization two to four months. Quadriceps exercise. Brace for additional two months. Complications to be treated accordingly.

PROGNOSIS—Satisfactory in uncomplicated cases. Amputation may be required in cases complicated by vessel injury.

INJURIES OF THE SEMILUNAR CARTILAGES

Injury to the Internal Semilunar Cartilage

ETIOLOGY—When the knee is flexed, externally rotated and abducted, the medial cartilage is drawn into the joint between the femoral and tibial condyles directly between the

weight bearing surfaces. The torsion strain then results in a shearing apart of the cartilage. The cartilage is split longitudinally with the free portion displaced towards or into the intercondylar notch. This is known as the *bucket handle type* of internal cartilage injury.

Other varieties are (1) a lax cartilage (2) a detached and displaced cartilage and (3) a tear of the posterior horn.

SYMPTOMS—*Bucket handle type* Pain in inner side of joint swelling due to joint effusion and recurrent locking.

Injuries of the posterior horn of the internal meniscus Pain on the inner side of the knee a deep clicking within the joint that cannot be localized effusion may or may not be present no true locking or unlocking syndrome a click can be heard by moving the lower leg forward and backward with the knee acutely flexed.

Injury to the External Semilunar Cartilage

ETIOLOGY—The mechanism of trauma to the external semilunar cartilage is an internal adduction strain of the tibia on the femur. The types found are (1) a complete detachment of the cartilage and (2) bucket handle.

SYMPTOMS—Pain and tenderness in outer aspect of joint loud snapping sound during acute flexion of knee and effusion only during acute episodes.

Treatment of Injured Semilunar Cartilage

In the peripheral tears where there is a good deal of vascularity healing may result from immobilization and elevation of the shoe on the inner border together with quadriceps exercise.

Injuries of the avascular region do not heal and therefore allow of redisplacement with recurrence of symptoms. In such instances excision of the cartilage is recommended especially after two or more attacks.

PREOPERATIVE PREPARATION—Teach the patient quadriceps exercise before entering the hospital.

OPERATIVE PROCEDURE—A tourniquet is a most useful adjunct for it allows a bloodless field with excellent vision of the operative field. It is not to be used however in patients with sclerosed vessels.

The operation is simplified by flexing the knee to right angle

A 2 inch parapatellar incision is sufficient for most cases if necessary this can be extended into the Fisher approach and the patella dislocated laterally

The cartilage should be removed whether it appears injured or not Thus one will not overlook an injury of the posterior horn This may necessitate an additional posteromedial incision

POSTOPERATIVE CARE—Application of pressure bandage consisting of sterile glazed cotton and flannelette or other semi elastic bandage Remove the tourniquet Apply either a posterior molded plaster splint or a complete circular plaster bandage from ankle to groin to be removed after thirty six to forty eight hours

Elevation of the limb for twenty four hours during which time an ice bag is applied to the side opposite the incision for twenty minutes every two hours Quadriceps exercises as soon as the patient is able to cooperate Active and passive exercises

The patient may be allowed up and about on the fourth day using crutches and bearing weight on the operated side On the seventh to tenth day the crutches may be discarded The average patient can return to light duties within two to three weeks following operation

PROGNOSIS—Excellent for complete recovery in those below forty years of age After age forty the knee usually loses 10 to 20 degrees of flexion

CYSTS OF THE SEMILUNAR CARTILAGE

ETIOLOGY—Trauma does not appear to be a direct cause of cysts of the semilunar cartilage Cysts are the result of a degenerative process occurring within the outer rim of the cartilage They then protrude laterally following the lines of least resistance They invade most often the mid third of the external cartilage beneath the external lateral ligament

SYMPTOMS—Aching pain in outer side of knee with localized tender cystic swelling which disappears on flexion of the joint The pain however is more acute during extension of the knee There is no history of true locking or snapping

TREATMENT—Excision of entire cartilage together with cystic mass

PROGNOSIS—Excellent

CALCIFICATION OF THE CARTILAGES

Calcified cartilages are not only very rare but they are asymptomatic unless injured. When subject to traumatism they are subject to the same signs, symptoms and treatment as is a normal cartilage that has been injured.

LOOSE BODIES IN KNEE JOINT

ETIOLOGY—Loose bodies in a knee joint may result from osteochondritis dissecans, chondrification of the synovial membrane with loose body formation, fracture of large osteophytic processes or fractures of the articulating surface of femur, tibia or patella.

SYMPTOMS—Pain, repeated locking and recurrent effusion following lockings. X-ray examinations reveal the position of the loose bodies.

TREATMENT—Removal of the loose body or bodies. The knee *must* be subjected to an X-ray just prior to the operation because the loose body may have shifted its position since the last examination.

PROGNOSIS—The prognosis depends upon the extent of the synovial disease found at the time of operation. If a synovectomy is performed in the elderly patient at the time of the removal of the loose bodies, one can anticipate some residual defect in motion. The removal of loose bodies may not influence the accompanying osteoarthritis.

RUPTURE OF EXTENSOR APPARATUS OF KNEE JOINT

ETIOLOGY—Direct injuries of the patella create fractures without interfering with the extensor apparatus.

Indirect violence results not only in a fracture of the patella but in an accompanying rupture of the extensor apparatus or in the following variations:

1. The rectus femoris tendon may be torn away from its attachment into the upper patella margin.
2. Avulsion of the patella tendon.

3 Separation of the tibial tubercle

4 Laceration of the capsule on either side of fractured patella

SYMPTOMS—The symptoms of *direct injuries of the patella* are pain hemarthrosis and local point tenderness. The x ray examination will yield evidence of stellate fracture.

The symptoms of *indirect violence* are pain hemarthrosis point tenderness and inability to extend the knee. The x ray findings are transverse fracture of the patella soft tissue infiltration without fracture upward displacement of the patella and separation of the tibial tubercle.

TREATMENT—Direct injuries are treated by immobilization for four to six weeks.

Indirect injuries are subjected to operative intervention and the necessary physical therapy.

PROGNOSIS—Excellent in those not affected with osteoarthritis.

SINGLE DISLOCATION OF PATELLA

ETIOLOGY—Single dislocation of the patella results from a sudden abduction and external rotation of the tibia.

SYMPTOMS—Pain and hemarthrosis. The patella is displaced laterally and the knee is maintained in extension so that it cannot be flexed either actively or passively.

Complications—In temporary subluxations a fragment of the articulating surface of the patella is torn free and acts as a loose body.

TREATMENT—In the simple case reduction is easily performed under anesthesia. When the injury is complicated by a fracture of the articulating surface of the patella the loose fragment is operatively removed.

PROGNOSIS—Excellent.

RECURRENT DISLOCATION OF PATELLA

ETIOLOGY—Faulty axial alignment of the quadriceps muscle and ligamentum patellae. This may be due to laxity of the capsule maldevelopment of the external femoral condyle or genu valgum deformity. The patella dislocates without any abnormal torsion strain.

SYMPTOMS—The dislocation causes pain swelling disability and a lateral position of the patella.

TREATMENT—Conservative care usually suffices. Radical therapy is indicated in all instances where recurrences are too frequent and disabling. Treatment consists in changing the line of force of the quadriceps muscle and patella tendon by slightly shifting the tibial tubercle medially.

INDICATIONS FOR EXCISION OF THE PATELLA

Comminuted fractures of the patella do not lend themselves to easy repair especially in those past forty years of age. For this reason excision of the patella may be indicated.

The other indications for excision are

- 1 Ununited fractures of the patella
- 2 Recurrent fractures of the patella
- 3 Recurrent dislocations of patella in individuals past forty
- 4 Old cases of fracture of the patella with secondary osteoarthritis of the anterior compartment
- 5 Disease of the patella osteomyelitis or tuberculosis aggravated or caused by injury

FRACTURE OF EXTERNAL TIBIAL TUBEROSITY

ETIOLOGY—There are two types of fracture of the external tibial tuberosity (1) the *depressed fracture* of the external tuberosity without involvement of the tibial articulating surface (2) the *comminuted fracture* of the external tuberosity complicated by a rupture of the internal lateral ligament and more rarely of the cruciate ligaments.

SYMPTOMS—The symptoms are pain, hemarthrosis, genu valgum deformity, lateral instability and disability. The x-ray findings are positive for fracture.

TREATMENT—Aspiration, manipulation, correcting the deformity, immobilization for three months and the use of caliper brace and physical therapy for one to three months. Open reduction is rarely necessary.

PROGNOSIS—The outcome will depend upon the degree of injury. In mild cases one can anticipate a 20 degree loss of flexion. In the more severe case there is a residual defect not only in flexion but of lateral instability. Delayed osteoarthritis must always be borne in mind in the more severe cases.

CASE REPORTS

The following case reports are for the most part atypical but instructive

Case I Internal Semilunar Cartilage Derangement Complicated by a Pedunculated Lipoma

F I a jeweler aged fifty two years was first seen July 27 1941 complaining of a painful swollen left knee of two days duration While descending a ladder he slipped off the third step twisting his knee Within a few hours he was disabled

Examination showed him to be walking awkwardly with his left knee flexed The entire knee was uniformly enlarged All movements were restricted flexion being possible for 30 degrees and extension lacked 20 degrees Although there was generalized tenderness one could localize one area of exquisite pain to the medial side midway between the patella and internal lateral ligament This persisted after the removal of about 60 cc of cloudy synovial fluid which remained sterile after seventy two hours The limb was encaased in plaster after x ray studies For the following ten days the patient suffered an elevation of temperature combined with local pain This subsided under sulfa drug therapy and bed rest

Laboratory studies at this time revealed a marked elevation of the sedimentation rate an increase in the white cell count and a corresponding leukocytosis

During the following weeks the knee assumed normal proportions and range of motion This however did not remain so and because of synovial fluid increase together with increasing disability the patient was prevailed upon to enter the hospital September 16 1941 and was operated upon the following morning Exploration revealed the presence of a large flat pedunculated, necrotic lipoma which was firmly attached to the main fat pad This was removed together with a thickened lax semilunar cartilage and several collections of fibrin from the quadriceps pouch The knee was subjected to the same postoperative care given in all instances of internal derangement The patient was discharged on the fifth day following operation getting about with crutches and in elastic bandage about the joint

Recovery was most uneventful and he returned to his trade within two weeks Re examination October 15 1942 disclosed a normally functioning and painless joint

This case represents the second instance of a pedunculated lipoma seen by the author resulting in symptoms indicative of internal derangement

TREATMENT—Conservative care usually suffices. Radical therapy is indicated in all instances where recurrences are too frequent and disabling. Treatment consists in changing the line of force of the quadriceps muscle and patella tendon by slightly shifting the tibial tubercle medially.

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Comminuted fractures of the patella do not lend themselves to easy repair especially in those past forty years of age. For this reason excision of the patella may be indicated. The other indications for excision are:

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PROGNOSIS—The outcome will depend upon the degree of injury. In mild cases one can anticipate a 20 degree loss of flexion. In the more severe case there is a residual defect not only in flexion but of lateral instability. Delayed osteoarthritis must always be borne in mind in the more severe cases.

and resisted extension of the knee caused pain localized to the site of tenderness

Roentgen ray studies. An anteroposterior view (Fig 120) on the left knee revealed the presence of an irregular calcification along the course of the internal lateral ligament and arising from the level of the adductor tubercle of the femur then extending downward for 2 inches

It was suggested that all physiotherapy be discontinued and that the limb be immobilized for four weeks. The patient was



Fig 120 (Case III) - Anteroposterior view of knee discloses calcification of the greater part of the internal lateral ligament

then permitted to have mild physiotherapy strapping and active and passive exercises to strengthen the quadriceps muscle. Within four months from the date of accident the patient had no subjective complaints. Extension was possible for 180 degrees and flexion to 90 degrees. His only complaint was the inability to completely flex the knee and because of this he was unable to return to his former occupation.

The patient remained under the care of his family physician until January 1947 approximately fifteen months following the accident and during this time he had not returned to work. The

insurance carrier then referred him to the writer for arthrotomy of the knee with excision of the calcification the idea being that if this were performed the patient would obtain sufficient flexion of the joint to permit him to return to his former occupation. On January 27 1942 the knee joint was explored. The internal semilunar cartilage appeared to be a trifle lax anteriorly but was not displaced or thickened. It was however removed because of its laxity. The calcified portion of the internal lateral ligament was then excised with the exception of a very small segment of bone immediately overlying the upper portion of the internal femoral condyle. The wound was closed in the usual manner using silk.

The following is a report rendered by the pathologist. The specimen is an ellipse of ligament about 5 cm in length 2.5 cm in width and 1 cm in thickness. At the center it has been broken apart and contains a mass of what appears to be cancellous bone. The rest of the ligament shows considerable calcification. Subsequent sectioning of the tissue shows a small bit of normal cancellous bone to which is attached a very dense piece of fibrous tissue. One portion of this fibrous tissue is covered with synovial membrane beneath which is a mild infiltration in some areas of lymphocytes and polymorphonuclear leukocytes. These collections lie right under the membrane and do not penetrate the fibrous tissue. (J. T. K.)

When last seen on August 5 1942 the patient walked without a limp. He was able to balance his weight equally well on either foot without complaint of pain. He however did not show any improvement in the amount of flexion at this time the range of flexion being 85 degrees and this was not sufficient to allow him to return to his former occupation. It is my understanding that he has not as yet attempted any form of work.

It is quite apparent that the operative intervention did not in any way materially influence the function of the knee.

Case IV Synovectomy with Fourteen year Follow up

W. W. F. a male accountant aged forty two years was first observed September 10 1926 because of a painful and persistently swollen right knee of two years duration. This had followed a twisting strain and had not been improved either by local or general antiarthritic measures.

Examination disclosed the following: Tall heavy set male walking with a slightly flexed generally swollen right knee. Angle of greatest extension 165 degrees angle of greatest flexion

80 degrees There was crepitation during movements of the joint Comparative measurements right knee $18\frac{1}{2}$ $18\frac{1}{2}$ and 15 inches left knee 16 15 and 14 inches in circumference

Roentgen ray studies merely showed the usual osteoarthritic changes common to his build and age period Guinea pig test of the synovial fluid was reported negative for tuberculosis Following six months of further conservative care a synovectomy was performed due to lack of improvement

Three months after operation the patient lost his position and has since become a chicken raiser He reported because of an other orthopedic problem October 10 1941 and his knee was found to be asymptomatic and freely moveable There has been no recurrence of his synovial irritation throughout the fourteen years

Case V Fracture of the Tibial Plateau Bone Block Limiting Extension

J L a boy aged eight years was first seen on August 10 1940 stating that on August 3 1940 he jumped off a trailer a



Fig 121 (Case V) —Lateral view of right knee showing presence of bone block secondary to fracture of tibial plateau

height of 5 feet and landed on the ground with his right knee in acute flexion He received emergency care and the application

of plaster encasement from the ankle to the groin. When examined on August 10, 1940, he was observed to walk with the right knee in an attitude of flexion of approximately 35 degrees and exhibited only 40 degrees of further motion. There was marked atrophy of both thigh and calf.

Roentgen ray examination disclosed the presence of a comminuted fracture of the tibial plateau with an irregular bone formation immediately in front of the spines of the tibia resulting in a mechanical impediment (Fig. 171). This accounted for his inability to extend the joint.

The patient was hospitalized and operated upon August 17, 1940, and the impediment removed. He received the usual after care and was last examined June, 1942. At this time he walked without a limp. He exhibited a normal range of extension but could not flex the joint for more than 120 degrees, thus exhibiting a loss of flexion of 20 degrees as compared with the normal knee. Aside from this there were no complaints. It is anticipated that in due time he will completely recover the normal motion of the knee joint without resultant disability.

Case VI Hemophilic Arthritis Aggravated by Traumatism

S. B., a male rental agent aged thirty-three years, was first seen January 22, 1941, because of a painful swollen left knee resulting from an accident on October 29, 1939. The history was that while arising from a kneeling position he struck his left knee against a concrete wall. This was followed immediately by swelling and difficulty with walking. Within a week, however, he returned to his occupation. His previous history is of interest insofar as seven years prior to the present accident he injured the same knee and was disabled for four months. He insists, however, that he was perfectly well during the intervening time.

The question in this case was whether the accident as sustained October 29, 1939, aggravated a preexisting disturbance.

The patient's chief complaints were a painful left knee, the pain being constant but worse when walking or climbing stairs. Examination revealed his gait to be normal. When standing his left knee was held a trifle in advance of the right. The left knee exhibited a loss of 10 degrees of extension and 20 degrees of flexion. There was distinct fullness along the inner aspect of the joint with moderate periarticular thickening and loss of normal knee markings. There was no anteroposterior or lateral instability.

X-ray examination. The anteroposterior views of both knees

disclosed the presence of a narrowing of the joint space with marked irregularity of both tibial and femoral condylar articular areas and cystic degenerative changes within the femoral and tibial condyles more particularly on the left side. In the lateral view the joint space between the femur and patella was also narrowed and the articulating surface of the patella was quite irregular (Fig 177)



Fig 177 (Case VI) —Anteroposterior view of left knee revealing disorganization of the joint narrowing of the joint space and cystic degenerative changes in hemophilic arthritis

These x ray findings in a young adult are indicative of a hemophilic arthritis. This diagnosis was subsequently confirmed by laboratory tests.

The prognosis in this type of case is poor since the arthritic changes are progressive and readily aggravated by minimal trauma.

Case VII Cyst of the Internal Semilunar Cartilage

M. S., a twenty six year old salesman was examined December 17, 1927, stating he had suffered an accident in January as a result of which he had never been completely free from pain. For the preceding four weeks he not only suffered pain and

disability but had noted the presence of a small localized swelling on the inner side of the joint

Examination revealed him to walk with a slight limp maintaining the left knee in an attitude of flexion of 15 degrees. The range of motion of the left knee was from 165 degrees of extension to 50 degrees of flexion. There was no evidence of lateral or anteroposterior instability and no synovial irritation. A small tender cystic swelling was found overlying the internal semilunar cartilage and slightly anterior to the internal lateral ligament. During flexion of the knee the swelling disappeared only to reappear during extension. The patient was subsequently hospitalized and operated upon and a cyst of the internal semilunar cartilage removed together with the entire cartilage. An uneventful recovery followed.

This patient was originally seen during May 1923 and was operated upon because of a fracture of the external semilunar cartilage involving the same knee. Up to the time of the accident of January 1927 he had been completely free from symptoms and had performed his regular work.

When last seen February 5 1933 because of a complaint far removed from his knee he had no symptoms referable to the knee and the examination was normal.

This case represents a very rare cartilage complication. Cysts are more frequently found invading the external cartilage.

Case VIII Recurrent Dislocation of Patellae

W. F. a student aged fifteen years was first seen December 10 1940 complaining of recurrent dislocation of the patellae. The history was that the patient was normal until the age of eight and from that time on with the slightest twisting strain the left patella would dislocate laterally. For the last two years the right patella had dislocated on two occasions as a result of similar injuries.

Examination. The patient was heavy for his age and both knees were in an attitude of 10 degrees of genu valgum. Both feet were pronated. Operation was performed on June 26 1941 and the patient was hospitalized for one month. At the time of operation the tibial tubercle of either knee was transplanted approximately $\frac{1}{4}$ inch medial to its normal attachment and maintained in position with a 2 inch vitallium screw (Fig. 123).

The patient has been seen on numerous occasions and when last examined September 16 1942 he had not suffered any recurrence although attending military school and partaking of all the routine activities.

EXCISION OF PATELLA—The author has excised five patellae. The first was performed for Paget's disease localized to the patella, the second for osteoarthritis secondary to old fracture of the patella, the third for recurrent fracture of the



Fig. 123 (Case VIII)—Lateral view of left knee disclosing displaced tubal tubercle maintained in position by vitallium screw

patella, the fourth for comminuted fracture of the patella and the fifth for recurrent dislocation of the patella. Only two will be reported in full to illustrate the problems involved.

Case IX Excision of Patella for Localized Paget's Disease

G. W. C., a salesman aged fifty-two years, was first seen February 23, 1939, complaining of painful right knee of many months duration. For the last three months the pain had been accentuated as a result of twisting strains suffered during the course of his employment. His history was negative for infection.

Examination. The patient walked quite well but exhibited a defect in extension of the right knee. There was no antero-posterior or lateral instability. The right patella was much larger and thicker than its fellow. Movements of the right patella on

the underlying femur resulted in crepitation and pain but there was very little restriction of motion of the patella itself. The popliteal space was thickened and one could here feel a large loose fragment of bone. The right knee measured $13\frac{3}{8}$, $14\frac{1}{8}$ and $12\frac{3}{4}$ inches and the left $15\frac{1}{4}$, 14 and 12 inches in circumference.

X ray studies of the skull and other bones throughout the body were negative. The right patella exhibited the appearance associated with Paget's disease. The patella was unusually dense and irregular. A large ovoid calcified shadow was seen in the posterior compartment of the knee (Fig. 124).



Fig. 124 (Ca. IX)—Lateral view showing calcified shadow of large loose body in posterior compartment.

This patient had received antiarthritic treatment which had no influence on his pain and had now reached the stage where he was fearful of losing his position because of his inability to get about and carry on with his work. He was therefore advised to allow of an excision of the patella and the loose body.

The operation was performed on March 2, 1939, and following removal of the patella and the loose body his limb was encased in plaster for two days. He was then encouraged to exercise the joint constantly. He was discharged on the ninth postoperative

day walking with crutches and within four weeks from the day of operation he had regained the complete use of his knee. He was able to return to his former occupation for limited periods of time and within a month resumed his full duties. This necessitated driving in automobile some 70,000 miles a year, a great deal of stair climbing and kneeling to inspect machinery. When seen August 1942 because of a sprained shoulder he stated he had no residual defects from the knee operation.

Pathologist's report. The specimen consists of a patella 8 cm in axial length, 4 cm in width and 2.5 cm in thickness. It has a peculiar overgrown wrinkled appearance reminiscent of elephant's hide. The articulating surface is very rough. Accompanying it is a piece of material resembling coral measuring 3 by 2 by 1 cm. Sectioning through the medial portion of the patella shows it to be made up of eburnated instead of cancellous bone which is alternately ivory white or a brilliant pink. The loose body is seen to be made up of a series of concentric lines about a central nucleus and undoubtedly represents a calcified joint body.

Microscopic examination of the sections from the patella reveals a mosaic appearance of osseous tissue. The osteoblasts within the lacunae are scattered and appear atrophic. There is marked fibrosis of the marrow and no hemopoietic tissue is present. This bone has the suggestive appearance of von Recklinghausen's disease. However, there are no bone cysts or giant cells. **Diagnosis:** Paget's disease.

Case X. Excision of Patella for Osteoarthritis Secondary to Old Fracture of the Patella

D. M., a housewife aged sixty years, was first examined December 1939, stating she had been suffering pain throughout the left knee for a period of years and had been unsuccessfully treated for arthritis. Twenty-five years ago she suffered a fracture of the patella which was operated upon and the injury had given her no trouble until about ten years ago. Since then the knee had become progressively painful and disabling.

At the time of examination she walked with the aid of crutches and maintained her left knee in an attitude of flexion of 20 degrees. She exhibited only 20 degrees of motion within the joint and the entire knee was enlarged (Fig. 125). All movements were accompanied by a great deal of crepitation and pain. The tenderness was localized about the patella. Excision of the patella was recommended and after due consultations she returned for

the operation. The patella was removed on April 5, 1940 and the following is a description of the specimen.

The specimen is a patella measuring 7 by 5 by 3 cm. It is covered by a shaggy aponeurosis which is apparently fixed to the underlying bone. The articular surface is studded with small knobs. The articular fat pad attached to one area is edematous. The bone flares out into a sharp rim. A section of bone was removed for further study and this section which has been



Fig. 125 (Case V).—Old fracture of patella with degenerative changes involving patella and articular surface of anterior knee compartment.

decalcified proves to consist almost entirely of fibrous tissue. Numerous giant cells may be seen throughout the section. A large number of blood vessels are present in the fibrous tissue. In lacunae and among the bands of fibrous tissue are the remains of degenerated bony trabeculae. Diagnosis: Fibrocystic disease of patella (S. G. A.).

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Fig. 125 (Case V).—Old fracture of patella with degenerative changes of articular surface and arthritis of anterior knee compartment.

decalcified proves to consist almost entirely of fibrous tissue. Numerous giant cells may be seen throughout the section. A large number of blood vessels are present in the fibrous tissue. In lacunae and among the bands of fibrous tissue are the remains of degenerated bony trabeculae. Diagnosis: Fibrocystic disease of patella. (S. G. A.)

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quently become loose and if this was not recognized and a new spica applied there would be a slipping at the fracture line with a loss of the proper reduction and an ultimate absorption of the neck. It can thus be seen that while the Whitman method was a real step forward in the treatment of this condition it left much to be desired.

Advantages of Internal Nail Fixation

If a fracture of the neck of the femur is not to be immobilized by some external means such as the Whitman spica it is apparent that internal fixation applied directly to the bone becomes a necessity. This use of internal fixation is not new although it is only within the past few years that it has become so popular. Round nails, square nails and all types of screws have been used off and on for many years with indifferent success. It was not until Smith Petersen in 1931 reported his ingenious three flanged nail that the problem of internal fixation was solved. The advantage of the three flanged nail lies in the fact that it combines the maximum of surface area with the minimum of displacement. Its length prevents angulatory movement and its flanges prevent rotatory movement. Some absorption along the path of the nail may occur so that the nail may slide longitudinally but it is still a three flanged nail and no rotatory or angulatory movements of the fragments are possible. The nail that Smith Petersen originally devised was made of stainless rustless steel. This was a great advance over the previous metals most of which set up ionization in the tissues with consequent reaction in the surrounding bone and loosening of the fixing device. At present most of the Smith Petersen nails in use are made of vitallium an alloy that causes no ionization in the body tissues. When such a nail is removed from a patient at the end of one or two years it has the same gloss and sheen as when inserted and shows no evidence of corrosion. Being a cast metal rather than a drawn metal it has the disadvantage of being somewhat brittle however and care should be taken not to drop a vitallium nail on the floor or subject it to undue strain before it is used.

Another method of internal fixation that is in common use today and one which gives excellent results is that devised

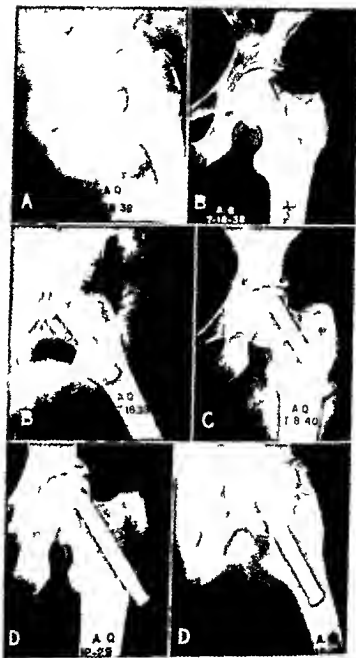


Fig. 126—*A* Intracapsular fracture of neck of left femur in a woman seventy years of age. *B* Anteroposterior and lateral views three months later showing Smith-Petersen nail in place with good position of the fragments but no union. *C* Anteroposterior view one year nine months after

by Austin Moore which consists in the fixation of the fracture by using four thin stainless steel wire nails driven through the neck of the femur and into the head. To prevent slipping each wire is fixed at the cortex of the femur with a threaded nut. This method has given good results in many hands but we have had no personal experience with it.

Physiological Considerations

A word should be said at this point as to why these fractures of the neck of the femur do not unite unless they are completely reduced and firmly immobilized. The answer can be summed up in two words—blood supply. The normal blood supply to the neck of the femur probably arrives by way of the capsule and the distal part of the neck and when the fracture occurs the capsule is torn and with it the normal blood supply to the neck from both sources is cut off. If complete immobilization is not maintained and motion is allowed at the site of the fracture and at the tear in the capsule it is impossible for new blood vessels to form and find their way into the proximal portion of the neck. As a result aseptic necrosis of the neck and head may take place. Engel and May have recently shown that new blood vessels may form along the path of the Smith Peterson nail. Sections of the neck taken from several of their patients who died several weeks following the insertion of the nail showed definite histological evidence of new blood vessel formation following the track of the nail.

Indications for Internal Fixation

Should all patients suffering from a fracture of the neck of the femur be treated by internal fixation? In answering this I should like to quote from Watson Jones who writes as follows:

In making the decision as to whether or not active treatment is indicated age itself need not be considered. Successful operations have been performed in many patients over

injury showing firm bony union. *D* Anteroposterior and lateral views four years eight months after the fracture occurred showing firm bony union with the Smith Petersen nail still in place. Note in the anteroposterior view that the nail has begun to extrude itself slightly. This patient however is still symptom free and so the nail has not been removed.

the age of 80 I have operated on two patients aged 91 and 92 both of whom one year and five years after operation are leading happy lives. An expectation of life amounting to no more than 5 or 10 years is no justification for the miseries of an untreated fracture; the old have as much right to live in comfort as the young. A nailing operation causes very little shock and if the immediate effects of the accident are survived and the general condition improves the question of active treatment must be seriously considered and seldom withheld.

It has therefore been our custom to employ the nail in most of our patients regardless of age unless there is some constitutional condition which would seriously threaten the patient's life if nailing were undertaken or unless the patient is so old and feeble as to preclude anything but the bed or wheelchair for the remainder of his life regardless of what were done.

Technic of Treatment with the Smith Petersen Nail

Our method of treating fracture of the neck of the femur may be briefly outlined as follows:

1 The limb is suspended with Russell traction with 10 pounds weight for a period of a week to ten days during which time the patient's general condition is evaluated and the local injury to the soft parts is allowed to subside.

2 At the end of this time the thigh is prepared for forty-eight hours by careful skin sterilization and encasement in sterile dressings. Adequate sterilization of the skin for at least two days before operation is a decided factor in minimizing the dangers of infections in these cases.

3 At operation cyclopropane or avertin and gas oxygen are our anesthetics of choice as both give adequate relaxation and are well tolerated by these elderly patients.

4 After the patient is anesthetized the fracture is reduced either by the Leadbetter or the Whitman technic. With the

In using cyclopropane or any other pleurotic gas great care must be exercised for portable x-ray apparatus. At the time that the x-ray machine is used in the operating room the patients' head and the chest mask and nesthete machine should be completely covered with a wet sheet. The corner of the sheet should always touch the floor. This will result in a minimum likelihood of pleurosis. This precaution is not necessary for avertin and gas oxygen is used as the nesthete agent.



Fig 127—A Man sixty seven years of age with subcapital fracture of neck of right femur B Anteroposterior and lateral views with Smith Petersen nail in place two months later C Anteroposterior and lateral views eleven months after fracture showing firm bony union

Leadbetter method the hip is flexed to a right angle and steadily lifted upwards. It is then internally rotated, abducted and extended. The fragments frequently lock and when the heel is rested on the surgeon's palm the foot and leg stay in a neutral position and the limb does not externally rotate. With the Whitman method steady traction is made on the limb with abduction, internal rotation and hyperextension at the hip. Both methods are usually successful in obtaining a reduction but if one fails the other should be tried.

5 The foot and leg should then be held by an assistant, steady traction being maintained with the thigh only slightly abducted and *the limb internally rotated 15 degrees*. In this position the neck of the femur in the lateral view becomes parallel to the table upon which the patient is lying and thus if the nail when driven in is kept parallel to the table it should traverse the length of the neck.

6 Reduction having been attempted and the foot and leg held in proper position by the assistant, a portable x ray machine is used in both the anteroposterior and lateral planes to make sure that an accurate reduction has been obtained.

7 If the reduction is satisfactory the insertion of the nail is then proceeded with; if unsatisfactory it is repeated. We use the so called "blind nailing method" which utilizes certain landmarks together with a small incision rather than open nailing which requires complete and extensive exposure of the neck and head so that the nail can be inserted under direct vision. The former method is much less shocking to the patient and is the one usually employed today.

Introduction of the Nail—The thigh is prepared and draped and a 3 inch longitudinal incision is made directly in the center of the outer side of the thigh. This incision starts at the greater trochanter and extends downwards for the necessary distance. A longer incision is sometimes required if the patient is very fat. The skin edges are protected with towels and the incision is carried down to the bone through the fascia and muscles. A punch hole is then made in the outer aspect of the cortex of the femur 1 inch below the greater trochanter. This is the point at which the nail is to be driven in. On the surface of the drape the midpoint between the spine of the pubis and the anterosuperior spine of the ilium

is now found and marked with a towel clip. This point is usually directly over the middle of the head of the femur. The limb is constantly held in the correct position by the assistant and *must always be maintained in a position of 15 degrees internal rotation*.

The driving of the nail now starts. It is pointed to the towel clip above mentioned and kept parallel to the table. Impelled by firm blows of the mallet the nail traverses the neck of the bone, crosses the fracture line and enters the head of the femur. Before the nail is driven completely in the procedure is halted, the operative field is covered with sterile sheets and another set of anteroposterior and lateral x rays are taken. If these show the nail to be traversing the neck and entering the head in the proper plane in both views it is driven completely home, the fragments gently impacted and the wound closed. If the path of the nail is unsatisfactory, however, it is withdrawn and started again, allowance being made for the error in position noted in the x ray films. Sometimes the nail is inserted perfectly the first time. At other times several attempts may be necessary before a satisfactory insertion is obtained. Proper position of the nail is essential, however, and the clock should never be a criterion as to when the operation should stop. The position of choice for the nail in the head is the middle or lower segment so that a valgus position may be obtained.

Selection of a Nail of Proper Length—The length of the nail to be used in each case is estimated before operation by taking an anteroposterior x ray of the good hip with a 1 inch lead marker laid along the side of the thigh. If in the x ray film the lead marker measures $1\frac{1}{4}$ inches we know there is a magnification of 25 per cent. The distance from the distal portion of the head to a point on the cortex 1 inch below the greater trochanter is then measured and this distance reduced by 25 per cent to give us the length of the nail required. In most instances we have found that the female requires a $3\frac{1}{4}$ or $3\frac{3}{4}$ inch nail and the male requires a $3\frac{3}{4}$ or 4 inch nail. Occasionally, even with careful estimation the nail selected will prove to be too short or too long. The nail should always be long enough to extend well into the head but should not be long enough to penetrate through the head into the hip joint. We had this happen in one instance.

Leadbetter method the hip is flexed to a right angle and steadily lifted upwards. It is then internally rotated, abducted and extended. The fragments frequently lock and when the heel is rested on the surgeon's palm the foot and leg stay in a neutral position and the limb does not externally rotate. With the Whitman method steady traction is made on the limb with abduction, internal rotation and hyperextension at the hip. Both methods are usually successful in obtaining a reduction but if one fails the other should be tried.

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Guides for the Nail—We do not use a directing Kirschner wire such as is sometimes used initially a cannulated Smith Petersen (Johannsen) nail later being driven over it since we feel this unnecessarily complicates the procedure and does not aid materially in directing the nail. A danger in this method is that of snapping off the Kirschner wire in its mid portion when the cannulated nail is driven over it and then driving the distal portion of the wire ahead of the nail up into the pelvis. This accident has occurred not infrequently. Neither do we use any of the many devices that have been developed to aid in directing the nail in the right path. We have found several of them unreliable and inefficient and feel that the more pieces of apparatus used the more things there are that have to be watched and the greater the possibility of error.

After care—Following the insertion of the nail the patient is returned to bed and is allowed out of bed in a wheelchair in a week or ten days. He is allowed to walk with crutches a few days thereafter and if he is made more comfortable thereby an ambulatory Thomas brace may be used. Unsupported weight bearing should not be encouraged for six months as the shearing action at the fracture site is thought to induce delay in union. In several of our Bellevue cases however in which intelligent cooperation is not always obtained we have found rapid union occurring when patients walked without support practically from the time of the operation. In general we may say however that unsupported weight bearing should be advised against until a ray evidence of union is present.

The nails are left in indefinitely and are not removed after union has occurred unless they become loose or unless they are causing the patient discomfort. In such cases the nail may readily be removed by opening a small part of the original incision under local anesthesia grasping the head of the nail with an extractor and withdrawing it.

$\frac{3}{4}$ to 1 inch longer. Fortunately it was long enough to cross the fracture line into the head a sufficient distance to obtain firm fixation. C. Antero-posterior and lateral views of the same patient taken one year eight months after the fracture occurred showing complete bony union with obliteration of the fracture line and bony trabeculae crossing from the neck into the head.

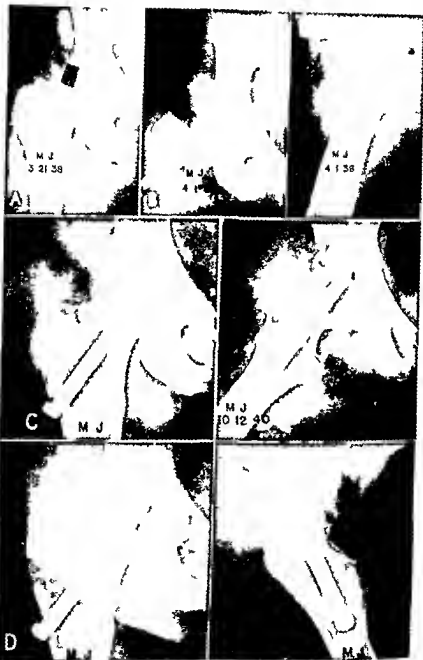


Fig 129—A Subperiosteal fracture of the neck of the left femur in woman seventy three years of age. B Anteroposterior and lateral views with Smith Petersen nail in place taken one month after reduction with insertion of

Results

The brief period of confinement of patients to bed the lack of stiffness of the knee and ankle the retention of normal muscle power and tone and the great improvement in the percentage of cases obtaining union speak highly for this method of treatment. Smith Petersen and his co workers in Boston report bony union in 70 to 80 per cent of cases followed over five years. It is too early yet, however, to assess a definite percentage of good results as a routine since enough observations on five year follow ups have not been reported. It can be definitely stated however that internal fixation is a long step forward in handling these patients and that the Smith Peterson nail offers one of the best of the available methods.

From 1937 through 1942 we have inserted the Smith Petersen nail in fifty eight patients with fractures through the neck of the femur. We have had two infections, one of which resulted in death. In the other infection it was necessary to remove the nail and nonunion resulted, although the infection ultimately healed. These cases were all intracapsular fractures and do not include any patients with intertrochanteric fractures.

There were thirty five women and twenty three men in this series showing a definite preponderance of the female over the male. The ages ranged from twenty eight years to eighty two years there being one man of twenty eight years another of thirty two years, and a third of forty years. The remainder ranged from fifty to eighty two years the largest incidence occurring in the group between sixty and seventy-five years.

There were two deaths one from sepsis as stated above and the other in a patient of eighty three years who succumbed to senility and malnutrition on the eighteenth post-operative day. There was no infection in this latter case as the operative wound healed by primary union and no fever

the nail. C Similar views two and one half years after occurrence of fracture showing firm bony union with trabeculations crossing from the neck into the head. D The same patient three and one half years after fracture with the nail in situ and no evidence of any late changes in the head. This patient is still active walking without any support and is free from any symptoms referable to the injured hip.



Fig 130—A Intracapsular fracture of the neck of left femur in sixty-seven years of age. Post reduction B Post reduction Anteroposterior and lateral views with Smith-Petersen nail in place C Twenty-eight months later showing beginning of osteoporosis of the femoral head of the femoral bone union at the site of fracture in the neck. The Smith-Petersen nail

was ever present. The mortality rate was 3.4 per cent. There were no operative deaths.

Of the fifty-eight patients treated by nailing, forty-nine obtained bony union while nine did not. Union was thus obtained in 84 per cent of the cases. In the cases of nonunion there was gradual absorption of the neck of the femur. One patient obtained excellent primary union but at the end of five years showed beginning vacuolization and aseptic necrosis of the head of the femur. Late changes in the head of the femur should be watched for and all of these patients should be followed for a period of five years. Flattening of the head of the bone or late aseptic necrosis may occasionally be seen.

As all of the patients in this series have not been followed for a full five years, it is not possible to estimate how many of the forty-nine patients who have obtained bony union may show later degenerative changes in the head of the femur. As over 75 per cent of the cases have already been followed over three years, however, it is reasonable to assume that the percentage of late changes in the head of the bone will not be large.

SUMMARY

- 1 In fractures of the neck of the femur internal fixation with a vitallium Smith Petersen nail is recommended.
- 2 Observations on fifty-eight patients treated by this method are reported on.
- 3 Forty-nine patients or 84 per cent obtained bony union while nine patients or 16 per cent did not. In the latter aseptic absorption of the neck of the femur resulted.
- 4 The mortality rate in this series was 3.4 per cent.
- 5 The functional results in those patients obtaining union were excellent.

was removed one year after insertion because it loosened and partly extruded. The patient was symptom free until October 1939 when pain began to develop in the injured hip. This was due to late changes in the head of the bone.

AMPUTATIONS IN RELATION TO EXTREMITY INJURIES

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and

JOHN H. MULHOLLAND, M.D.†

In the peacetime practice of most surgeons and of the surgical services of the average general hospital amputations are relatively uncommon and are usually performed for diseased rather than traumatized extremities. For this reason beyond the Callander operation which was given to the profession in 1935 no important advance in the operative technique of amputations has been made since the First World War. Consequently most of the material in this paper on operative procedures has been drawn from the experience gained in that conflict.

This however is not to say that in this special phase of surgery no recent progress has been made nor that it has nothing to profit from the latest advances in general surgical practice. Thus the closed plaster cast method for the immobilization of compound fractures and the use of the sulfonamides have narrowed the range of indications for amputations. And newer knowledge which has been gained in anesthesia, in the use of blood and plasma transfusions, in the management of shock, in the prophylactic use of the sulfonamides against infections in operative wounds and in the relation between protein deficiency and wound healing is equally applicable in this field of surgery as in any other. A discussion of some of these general measures will appear in the latter part of this paper.

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Classification—In general the circumstances necessitating amputation may be broadly classified under the general headings of emergency and elective

INDICATIONS

The indications for *emergency amputation* are limited to severe trauma alone. The varieties may be summarized as follows

- 1 Traumatic amputation i.e. trauma to an extremity so severe or of such a nature as in effect to have already produced an amputation
- 2 Crushing injuries of the soft parts or compound fractures associated with loss of the main blood supply to the part below
- 3 The pinning of extremities under the debris of a fallen building from beneath which it is impossible to extricate the individual by any other means⁶

It is to be noted that compound fractures in which a portion of the bone is missing is not included as an indication since it has been found that in many instances subsequent bone grafts can replace the missing fragments

The indications for *elective amputation* may be summed up as follows

- 1 Severe mixed infection in contused and lacerated soft parts not responding to adequate therapy
- 2 Gas gangrene infection which has not responded to adequate incision and drainage and therapy or drugs
- 3 Severely infected and comminuted fractures involving joints
- 4 Chronic osteomyelitis not responding to therapy
- 5 Recurrent hemorrhages or gangrene from damage to the main circulation of the limb^{1 16 19}

GENERAL PRINCIPLES

There are certain general surgical principles which are basic to all amputations. The two most important are (1) *the saving of life* and (2) *the saving of limb function*. While generally it will be possible to follow both of these principles in any one case the emergency may be so acute that the latter must be sacrificed for the former. However, when the

individual's life is not in danger and the circumstances are favorable a less speedy but more conservative operation can be done which will be productive of good functional results without resorting to a secondary operation.

Technical Considerations—Next in importance to these two basic principles are several important technical considerations. Foremost among these is the *time elapsing between injury and operation*. There appears to be some difference of opinion as to whether primary closure of amputation wounds should be done under battlefield conditions. Some authors state that a closed amputation may be performed up to six hours after injury⁶ others state that a primary closure should never be attempted but that the wound should always be left open.⁵ What makes the field of amputations following trauma complicated is that while considering the immediate surgical problems presented at the time of operation the surgeon at the same time has to plan an operative approach which will give the resulting stump its maximum functional efficiency. In order to do so the principles of prosthesis making must be understood.

The useful portion of a *stump* insofar as prosthesis wearing is concerned lies between the point of insertion on the shaft of the muscles arising above the proximal joint and the viable end below. The longer the length of shaft between these two points the greater the leverage obtainable. Consequently a prosthesis fitted to a long stump is more efficient than one fitted to a short stump. Another consideration is that when a maximum amount of limb length is saved there remains some margin for reamputation at a slightly higher level if some complication should arise.¹

It is apparent that the level of section through the bone determines the functional strength of the stump and also the level of the *skin flaps*. The latter must cover the bone end adequately and without tension since skin flaps usually retract considerably. Flaps are also formed so that the suture line lies outside any point of pressure being placed either anterior or posterior to the weight bearing area depending upon the part involved.¹

Early *ligation of the blood vessels* either with or without the use of a tourniquet tends to minimize the danger of shock.

According to Holman, squeezing the artery empty with the fingers before the ligatures are drawn tight prevents fracturing the wall which sometimes occurs in a distended vessel.³¹ The *nerves* are cut somewhat proximal to the line of incision and are injected with absolute alcohol. Various authors differ on the treatment of nerves but the majority find that this treatment with absolute alcohol seems to be the best prophylaxis against neuroma formation.¹

In *cutting through bone*, stress must be laid first upon gentle retraction of the muscles so that they are not torn from the periosteum and secondly upon an avoidance of stripping back of the periosteum beyond the saw line.¹ Taking these precautions prevents the formation of bony spurs which are one of the causes of painful stumps. The periosteum is cut clean with a knife $\frac{1}{4}$ inch proximal to the sawed end of the bone. The projecting aperiosteal bone end is then rounded off with a rasp. All bone dust must be thoroughly washed out of the wound by saline irrigation. Bone wax should not be used to stop bleeding from the marrow unless absolutely necessary since it acts as a foreign body. Mechanical pressure or a small piece of contused muscle applied to the bleeding area will usually suffice. Arterial bleeding from bone is best controlled by crushing with a clamp the wall of the bony canal in which the artery lies against a cortex.^{1, 3}

When a *reamputation* or a *plastic closure of a previously infected stump* is contemplated a prophylactic dose of antitetanus and gas bacillus serum should be given since a quiescent focus may be reactivated by the surgical procedure.¹

UPPER EXTREMITY

Hand

Obviously the hand is functionally the most important part of the upper extremity. Loss of it or any of its digits seriously injures the usefulness of the upper extremity and handicaps the individual. In the upper extremity a prosthesis is not as satisfactory as in the lower. Kessler in a six year follow up of 230 cases of upper extremity amputations found that at the end of that time only 12 per cent wore artificial arms and only 6 per cent used them for work.⁴ The complex gradation of movements of the hand is impossible to reproduce in a

prosthesis. Because of this a position of extreme conservatism regarding treatment and amputation of the upper extremity has to be maintained.

Almost all amputations of fingers or hands should fall under the heading of elective amputation.¹¹ Traumatic amputation due to machinery or explosives may preclude the observance of this principle. But in mangling and crushing injuries of the fingers and hand with or without compound fractures every attempt should be made to save the member. Conservatism is aided by the presence of an excellent blood supply since the superficial and deep volar arches, the dorsal arch and the volar interosseous artery all anastomose to such a degree that both radial and ulnar arteries may be cut and the hand remain viable (Fig. 133).⁸

The functional value of the various digits must also be considered in the treatment of hand injuries. Loss of the thumb destroys one half of the function of the hand and the loss of the thumb and first finger almost completely destroys the usefulness of the hand.¹ However the presence of the thumb and one or more digits such that apposition can be effected is better than any prosthesis thus far devised. The use of a glove prosthesis with artificial fingers or an artificial thumb such that either the thumb or fingers has a surface for apposition does have some merits.⁹ The main guiding principle with respect to the digits is *the swing of finger or thumb length*. The loss of the tip of the finger or the distal phalanx is a serious loss to skilled workers.¹²

The factor of the time interval between injury and operation holds the same for the hand as elsewhere. A wound less than six hours old is only potentially infected and responds well to mechanical cleansing and debridement.

Traumatic Amputation through Tip of Finger—Traumatic amputation through the tip of the finger may be treated in several ways. A flap including subcutaneous fat may be turned back on the palm under local anesthesia and sutured to the tip of the finger as a full thickness graft as the finger is flexed on the palm. (Sutures may even be placed through the finger nail if necessary in which case the skin flap will heal flush with the nail.) This method restores pulp and thick skin to a member which would otherwise be poorly protected. After

two weeks the graft is freed from its palmar pedicle and the palmar wound closed after undermining the skin edges.¹³

Another method of treatment is to make a thimble of sterilized x ray film about the finger tip so that granulations grow within this cylinder. There will be partial epithelization of the edges of the wound and after ten days the remaining surface may be covered by one or two pinch grafts.¹⁴

A Thiersch graft from the forearm may be cut and sutured in place at the time of debridement. However, this type of graft breaks down under wear and tear.¹⁴ Still another method offered is that of forming a sliding graft from the adjacent skin to cover the defect at the tip the donor site being covered with a Thiersch graft.¹

Traumatic Amputation of Distal Phalanx—Traumatic amputation of either of the two distal phalanges may be treated similarly. Where there is crushing of the bone between two joints the loose fragments may be removed and the solid portions impacted. This produces a somewhat shorter digit but by shortening fascia and tendon a marked swing in finger length can be effected.¹

Closure by primary flap formation necessitates considerable sacrifice of bone length to obtain adequate stump closure. The flap should measure twice the diameter of the stump in total length.⁸ A flap closure of a traumatic amputation of the fingers should only be used when bone has been torn out leaving sufficient skin behind.

Mangled Hands with Broken Bones—Contused and lacerated hands with compound fractures of phalangeal or metacarpal bones are best treated by thorough cleansing with soap and water saline irrigations and meticulous debridement. A bloodless field should be maintained by means of a blood pressure cuff inflated above systolic blood pressure after the arm has been elevated to drain it of blood. In this way a thorough exploration for severed tendons and nerves may be done.¹⁵ These latter are repaired with silk if the time elapsing since injury is short. Some authors advise an immediate Thiersch or a split thickness graft over denuded areas if there is sufficient vascularity present to support the graft.¹⁴ Piecrust holes are made in any skin flaps or grafts for drainage. Sulfanilamide crystals are sprinkled throughout the wound

and vaseline gauze is applied and with Kirschner wires through the distal phalanges the hand is put up in plaster in a banjo splint with rubber band traction. The wounds are not dressed for about three weeks (See Figs 131 and 132).

Elective Amputations through Fingers or Thumb—The indications for elective amputations through the fingers are (1) bone and joint infections and (2) stiff fingers. By the use of long palmar and short dorsal flaps the resulting scar is



Fig. 131—Admission x-ray of a hand right in a m. h. n. The x-ray shows extensive avulsion of the skin of the palm and the dorsal surface of the lower third of the fingers. Tendons and nerves were lacerated and the phalangeal and metacarpal fractures were compound.

placed outside of areas of active contact. The tendons are sutured to their sheaths or to the periosteum on either side of the bone rather than end to end across the bone. In this way the pulling sensation associated with the latter method is avoided.¹⁰⁻¹⁴ Disarticulations through the distal and proximal interphalangeal joints are treated in the same way. In all cases the nerves are isolated and cut short to avoid their inclusion in the scar.

Disarticulation at the metacarpophalangeal joint yields a stronger but less cosmetic hand than does resection of the metacarpal head.¹¹ A racket shaped incision is made with the tail over the dorsal aspect of the metacarpal bone. The palmar aspect of the curved incision should be notched in a heart shaped pattern so that after closure a rib of skin does not project from the palmar surface (Fig. 134). Loss of a single finger at this level is best treated by resection of the meta-



Fig. 133—Post reduction x ray of the same hand after debridement and application of rubber band traction to Kirschner wires in the distal phalanges by means of a banjo splint and with immobilization in plaster

carpal head permitting the remaining fingers to draw closer together. In amputations of the forefinger or little finger the metacarpal head should be removed through a laterally placed racket shaped incision and the shaft of the metacarpal bone beveled off. This produces a cosmetically tapered hand.^{1, 14} If two or more adjacent fingers are lost the metacarpal head should be saved. Loss of the first two metacarpal bones is more serious than loss of any of the others.

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Elective Amputations through Fingers or Thumb—The indications for elective amputations through the fingers are (1) bone and joint infections and (2) stiff fingers. By the use of long palmar and short dorsal flaps the resulting scar is



Fig 131—Admission ray of the hand. The patient was a 40-year-old male with a long history of rheumatoid arthritis. The patient had a long history of rheumatoid arthritis and had been treated with various medications. The patient had a long history of rheumatoid arthritis and had been treated with various medications. The patient had a long history of rheumatoid arthritis and had been treated with various medications.

placed outside of areas of active contact. The tendons are sutured to their sheaths or to the periosteum on either side of the bone rather than end to end across the bone. In this way the pulling sensation associated with the latter method is avoided.^{10,14} Disarticulations through the distal and proximal interphalangeal joints are treated in the same way. In all cases the nerves are isolated and cut short to avoid their inclusion in the scar.

Disarticulation at the metacarpophalangeal joint yields a stronger but less cosmetic hand than does resection of the metacarpal head.¹¹ A racket shaped incision is made with the tail over the dorsal aspect of the metacarpal bone. The palmar aspect of the curved incision should be notched in a heart shaped pattern so that after closure a rib of skin does not project from the palmar surface (Fig. 134). Loss of a single finger at this level is best treated by resection of the meta-



Fig. 137—Post reduction x ray of the same hand after debridement and application of rubber band traction to Kirschner wires in the distal phalanges by means of a banjo splint and with immobilization in plaster

carpal head permitting the remaining fingers to draw closer together. In amputations of the forefinger or little finger the metacarpal head should be removed through a laterally placed racket shaped incision and the shaft of the metacarpal bone beveled off. This produces a cosmetically tapered hand.^{1, 14} If two or more adjacent fingers are lost the metacarpal head should be saved. Loss of the first two metacarpal bones is more serious than loss of any of the others.

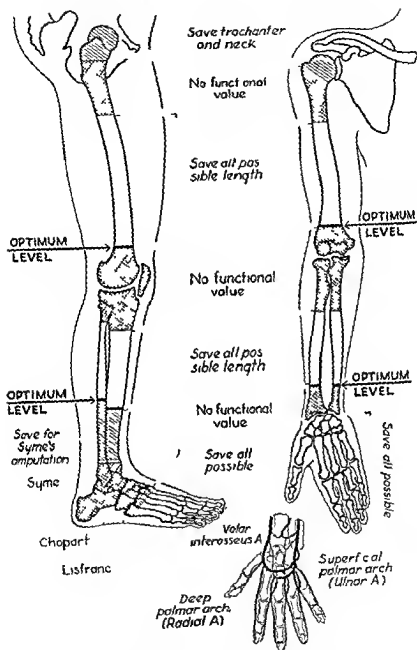


Fig. 133—Sites of selection for amputations in both upper and lower extremities (Modified from *Textbook of Surgery* by Dean Lewis Syme). The anatomical arrangement of the bones and the arrangement of the arteries of the hand is also shown.

The thumb is treated in the above manner except that an even more conservative attitude toward the preservation of bone length should be maintained. Even a stiff thumb if it has been kept in the position of function i.e. in moderate flexion and apposition is better than none at all. Even with loss of the distal phalanges of the thumb a plastic operation involving freeing of the metacarpal bone from the web will produce a stump with grasping function.¹⁴

The loss of all the fingers with only their metacarpal stumps remaining has still many advantages over a prosthesis. Even if traumatic amputation has left only the carpal bones a rather useful stump which has some mobility still remains.¹

Forearm

In amputations through the forearm the site of election is at the junction of the lower and middle thirds (Fig. 133). The blood supply to the stump is not good below this level and the fitting of a prosthesis yields a hand longer than that on the opposite side. Anterior and posterior flaps of equal lengths may be made since a terminal scar is of no importance where no end pressure is applied. The shortest stump possible is one terminating $1\frac{1}{2}$ inches distal to the insertion of the biceps tendon on the radius.^{1, 3}

Upper Arm

Disarticulation through the elbow joint results in a bulky stump requiring considerable skin to cover it and causing a disproportionate arm length if a prosthesis is fitted over it. The site of election in the upper arm is through the lower third about 2 inches above the epicondyles. Any amputation above this level results in a stump with weak leverage hence the necessity of saving as much bone length as possible as the shoulder joint is approached. The shortest stump to which an effective prosthesis can be applied is one extending 2 inches below the anterior axillary fold.^{1, 3}

Resection through the surgical neck gives a more cosmetic appearance to the shoulder than disarticulation of the humeral head. For this operation an anterior racket shaped incision is used (Fig. 134). However no functioning prosthesis can be worn from this position. A shoulder girdle amputation with resection through the clavicle at the junction of the inner and

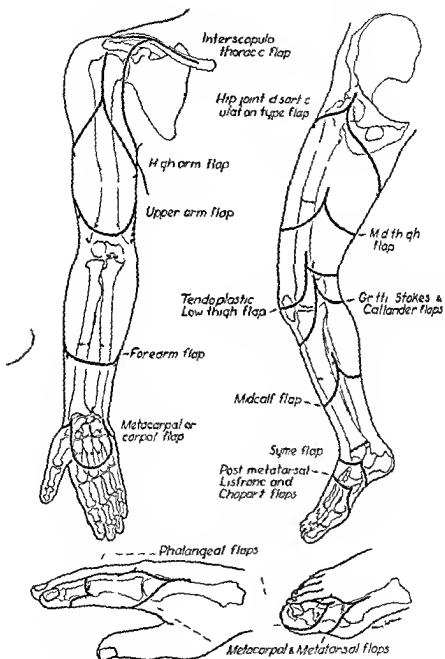


FIG. 134.—Diagram showing the position of the various flaps for amputation of the leg of a horse, the site of laceration shown in Fig. 133.

middle thirds and with excision of the scapula is a rarely used procedure (Fig. 134). In this case the subclavian artery and vein are ligated early to control the blood supply.¹

LOWER EXTREMITY

The functional considerations of the lower extremity are different from those of the upper. The function of the lower extremity is mainly that of weight bearing and the complex mechanisms of motion possessed by the hand are absent here. A prosthesis therefore has only the comparatively simple function of weight bearing to perform. For this reason unlike the situation with reference to the hand a prosthesis is to be preferred to a crippled member. This statement nevertheless should not be used as an argument against the conservative treatment of lower extremity injuries.

Traumatic Amputations—In the lower extremity also the conditions demanding immediate amputation are comparatively small in number. Traumatic amputation and damage to the main blood supply of the leg as a result of crushing injuries constitute the most common types of trauma necessitating emergency surgery. Traumatic amputation in itself is a form of guillotine amputation and many times may be treated as such. The stump end resulting from a traumatic amputation caused by explosives is debrided and packed open with one of the sulfonamide drugs and vaseline gauze. Adhesive traction is then applied to the skin. In this way maximum bone length is saved enabling a second amputation to be done at a site of election at a later date.¹

Guillotine Amputations

The guillotine amputation per se is a vertical section through the leg at a point a short distance above the site of injury. The flaps are retracted somewhat after each stroke of the knife so that a concave surface results with the bone in the center of the concavity. The periosteum is cut clean with a knife flush with the muscle and the bone is sectioned level with the cut surface of the muscle. The raw surface is sprinkled with crystals of one of the sulfonamide drugs and vaseline gauze packing is applied as mentioned before. Skin traction in the form of four adhesive strips is applied to the

skin of the stump from the edge of the wound to some distance back. The long ends of the strips projecting over the stump are fastened over spreaders. A rope is run from the spreaders through a pulley at the end of the bed. A weight is suspended from this end of the rope as a means of traction.

In this type of amputation in the treatment of traumatic amputations as described before and also in the closed procedures in which the suture line has opened it is absolutely necessary to apply *traction* early and to maintain it adequately. Traction is best applied at the time of operation and should be delivered no more than twenty four hours at the most.

This entire procedure is used when the time between injury and operation has been longer than six hours and also when circumstances are not suitable for a closed type of amputation. Kirk states that the guillotine operation is the method of choice under conditions of war. It also has as its main purpose the saving of limb length so that reamputation at a site of election may be done at a later date. It is to be noted that British surgeons prefer an oblique circular incision with a long overhanging anterior flap to the vertical type of guillotine amputation.³ Another modification of the guillotine operation is the sleeve operation for gangrene of the lower leg following a fracture of the femoral shaft with damage to the artery. A circular incision is made above the knee down to the bone. The distal fragment of the femur is then separated from the fracture site and the wound packed open.³

Previously one of the disadvantages associated with the guillotine operation was the severe pain associated with the daily dressings. With the present tendency to change dressings less frequently made possible by the use of the sulfonamides this disadvantage has disappeared. The wounds so treated are usually sterile on the seventh to tenth post operative days. With skin traction strictly maintained healing occurs in four to six weeks with the skin edges so well coapted that a secondary operation is not necessary and a prosthesis can be worn.⁴

Treatment of Unhealed Stumps—In guillotine amputation stumps which have not healed completely two procedures may be used to obtain healing so that a prosthesis may be

worn. These are plastic closure and plastic resection of the granulating area. At least six months of healing should intervene between injury and use of either of these methods. In addition any draining sinuses or x ray evidence of osteomyelitis of the bone end should be treated and eliminated before a closure is attempted. There should be no edema of the stump and cultures should be negative specifically for streptococci. Tetanus and gas bacillus antiserums should also be given at the time of the operation.

The procedure of *plastic closure* involves excision of the area of granulations and perhaps a thin slice of bone from the stump end. The skin edges are first undermined and then approximated over the defect without undue tension. Split thickness grafts are not employed here because they break down easily in such locations. A second procedure namely *plastic resection*, is simply a more extensive excision of a block of granulations and bone with closure of the defect in layers.

Pressure dressings are applied to the stump following either of these procedures. If the area involved is on a stump below the knee a posterior splint or plaster cast is applied for at least a week. The stump is elevated on a pillow. If there are signs of breakdown of the skin edges adhesive traction is applied. By use of these latter methods a useful stump may be obtained without the sacrifice of considerable bone length as would be necessary in a reamputation.⁵

As in the upper extremity elective amputations at sites of election are done most frequently in cases which have been treated conservatively and where chronic infection or gangrene has ensued. While in most of these cases primary closure is the rule under conditions of advancing sepsis such as gas gangrene a guillotine amputation is the only procedure advisable. Wide open drainage of infected muscle planes has to be established as a life saving procedure.³

Amputations of the Toes

Functionally speaking, amputation of the toes is of minimal importance as compared to that of the fingers. Loss of the great toe, however, does make walking somewhat difficult due to the absence of its lever action. The technic for amputation of the phalanges of the toes is similar to that of the

fingers. A long plantar flap and a short dorsal flap are formed in order to keep the scar away from the weight bearing surface. The tendons are sutured to the periosteum of the bone stump. A disarticulation of the toe from the metatarsal head is done by means of a racket shaped incision with the tail over the dorsum of the metatarsal head. The distal curved incision is carried down to the plantar surface just beneath the first interphalangeal joint. The tendons are sutured to the joint capsule. The metatarsal heads should be preserved if possible since they form the anterior portion of the arch of the foot. All the toes may be disarticulated en masse and a long plantar flap formed to cover the metatarsal heads. Sutures should be left in place ten days or longer since the skin is very thick and heals slowly.

Tarsometatarsal and Mediotarsal Amputations

The shortest foot stump compatible with any degree of function is a section through the base of the metatarsal bone (Fig. 133). Any section posterior to this line gives an equinus deformity due to overpull of the unopposed Achilles tendon. It is for this reason that the tarsometatarsal amputation of Lisfranc and the mediotarsal section of Chopart have been discarded. A Syme's or a midcalf amputation yields better results.¹

Amputations at the Ankle

Syme's Amputation—The Syme's amputation in disfavor for some time has been found to give good functional results when performed carefully and when uncomplicated by infection. In this procedure the entire foot is amputated and the ankle joint opened. The os calcis is dissected out special care being taken not to injure the posterior tibial artery or to cut through the skin flap. The tibia and fibula are cut through $\frac{1}{2}$ inch above the articular surface (Fig. 133). The heel flap with the fat pad intact is then sutured over the bone ends accurately so that there is neither undue tension nor redundancy of the tissues.¹⁷ Adhesive plaster pressure dressings or a plaster cast is kept in position for two to three weeks so that there is no motion of the flap during the period of healing.^{17, 3}

This type of amputation results in an end bearing stump

which can be walked on without the use of a prosthesis, if necessary. However, it should not be done as a battlefield procedure because of the danger of infection or danger to the circulation both of which are conducive to poor results.¹ It is not an objectionable amputation in men since the disfigurement of a bulky ankle produced by the prosthesis is covered by the trouser cuff. In women however an amputation at a higher level is desired for cosmetic reasons.

Pirogoff's Osteoplastic Amputation—The Pirogoff osteoplastic operation is a modification of the Syme's. It was devised to obviate the difficulty of dissecting out the os calcis without injuring the blood supply to the flap. The os calcis is cut across with a saw and its raw surface apposed to the cut surface of the tibia and the fibula as described above. The fusion of these two bones is essential for the production of a good result namely an end bearing limb. However osteoplastic operations take longer to heal and are subject to more complications than the flap operations. The Syme's gives a better final result.¹

Amputation at Middle Third of Lower Leg

The next site of election for amputation of the lower extremity is the middle third of the lower leg. As in the fore arm the tissues distal to this point are not sufficiently well supplied with blood to render a flap operation feasible. The optimum stump length is five to seven inches below the point of insertion of the hamstring muscles when the knee is in 90 degrees flexion. A long anterior and a short posterior skin flap are fashioned so that the scar rides posteriorly. The anterior surface of the tibia is first beveled off so that it will not cut through the flap. The fibula is cut 1 inch higher than the tibia. In stumps of 5 inches or less in length the fibula is excised since its presence frequently gives rise to pain when a lateral weight bearing prosthesis is worn. The fascia over the gastrocnemius is brought forward and sutured to the anterior layer over the bone end. The shortest functional stump length is $1\frac{1}{2}$ inches below the insertion of the hamstring muscles on the tibia.

In performing this amputation the patient may be placed in a semiprone position on the operating table so that the leg

on flexion at the knee points upward presenting a much more convenient working position than in the usual supine position.¹⁸ Following the operations in all amputations below the knee the extremity must be splinted for about three weeks to prevent a flexion contracture of the stump. A plaster cast applied at the time of the operation accomplishes this purpose.³

There is some difference of opinion about the relative merits of the midcalf as compared to the low thigh amputation. Gallie states that in the Canadian army the Gritti Stokes is the preferred type but Kirk in the American army favors the midcalf.¹ However when a bilateral amputation has to be done the midcalf type is preferred to the low thigh since the loss of both knees is a serious handicap.

Amputation at Lower Third of Femur

The lower third of the femur is the site of election in the upper leg. There are several operations in use each one of which has certain advantages.

Gritti Stokes Amputation—The Gritti Stokes has been found to give good results over a long period of time.¹ In this operation anterior and posterior flaps are cut at the level of the tibial tubercle. The quadriceps tendon is severed at this level and turned back. The inner surface of the patella is then cut flat with a saw and apposed to the cut end of the supracondylar portion of the femur. The patellar tendon is then sutured to the hamstring muscles. Here again the success of an end bearing stump depends upon the fusion of the two bones. In the simpler *tendoplasty procedure of Kirk* the danger of nonunion of the two bones is avoided. In this latter operation the patella is excised and the quadriceps tendon alone is drawn across the amputated end of the femur and sutured in place.

Callender's Operation—The Callender operation permits a primary closure of the amputation wound in the presence of infection in the leg below the site of amputation. The principle of the operation is based upon the anatomic fact that the popliteal space is a closed space as long as the bellies of the muscles are not severed. In this operation this principle is respected by severing only the tendons of the hamstring

muscles the incision being made just above the insertion of the tendons on the tibia. The patellar tendon also cut at its insertion is drawn across the end of the supracondylar portion of the femur but no sutures are used to hold it in place.¹ The skin is closed loosely by a few interrupted sutures (Figs 133 and 134).

A *modification* of the Callander operation has been reported recently. It differs from the original in that the bone is severed more proximally, i.e. in the medullary rather than in the cancellous portion of the femur. The quadriceps tendon is cut through above the patella and only subcutaneous fat and skin are used to cover the cut end of the bone instead of muscle or tendon as in the previous amputations. The rationale is that no natural weight bearing surfaces such as the heel, toes or fingers are covered by anything other than subcutaneous fat and skin. The long skin flaps are also closed loosely to permit drainage. The wound in either the Callander operation or its modification can easily be packed open if the possibility of infection in the wound itself is present.⁴

It may seem paradoxical that the long skin flaps extending several inches below the point of ligation of the femoral artery remain viable. The reason for this is that the skin is supplied by the profunda femoris artery which arises from the common femoral high above the point of ligation of the femoral.⁷

Amputations near or at Hip

Although in amputations of the femur the lower third of the thigh is the site of election functional stump formation is possible up to a distance of *3 inches below the groin*. At these higher levels it is not so important to have the scar come posteriorly since the shorter stumps are not end bearing. The weight is borne on the ischial support of the prosthesis and on its sides. As in the upper extremity the shorter the stump the weaker the leverage hence the necessity of conserving bone length above the level of the lower third.

Stumps shorter than three inches offer no advantage over a straight *hip joint disarticulation*. But the term must not be taken too literally for in performing this operation all authors stress that the neck of the femur or even the trochanters

should be left in place if possible. This forms a projection which will fit into the socket of a tilting table seat so that a prosthesis may be worn. The incision used is racket shaped with the tail placed anteriorly over the femoral vessels which are ligated early in the operation. The loop of the incision is brought around posteriorly and as far away from the rectum as possible³ (Fig. 133).

RECENT TRENDS

The recent tendency to use *silk and cotton for suture material* in amputations has necessitated the gentle handling of tissues and absolute hemostasis. This technic has made it possible to close amputation stumps tightly and without drainage.²⁰ *Sulfamylamide crystals* have also been used in uninfected cases as a prophylactic against secondary infection. What results these two modifications of technic will produce under war conditions remains to be seen.

As a result of the increasing interest in physiology on the part of the surgeon several new concepts have arisen in the field of surgery. The one which seems to have considerable value with respect to amputations is that of *local tissue metabolism*. For some time it has been known that the metabolism of dogs in shock was reduced since their body temperature and oxygen consumption were found to be low.¹ Recently observations have been made by Blalock on the effect of raising and lowering the environmental temperature of dogs in shock. The dogs exposed to low temperatures survived longer than those exposed to elevated temperatures.² When the injured limbs of a series of dogs in shock were packed in ice these dogs survived longer than those whose extremities were warmed.³⁰

In patients with arteriosclerosis Allen has shown that the blood supply is diminished to such a degree that only tissues with a low metabolic rate are adequately supplied with oxygen. Anything which causes an increased metabolism in any portion of the tissues of an arteriosclerotic extremity will put a demand on the blood supply which the latter is incapable of meeting. Hence walking by individuals with peripheral arterial disease provokes the symptom complex of intermittent claudication. Likewise in such individuals local

infection increases the local metabolism and may cause anoxia of such a degree that gangrene results.⁴

Refrigeration Method in Treatment of Injuries of Extremities

The same mechanism is that described in the previous paragraphs operates when a tourniquet is applied to an injured limb shutting off its blood supply. Any environmental rise in temperature then causes a concomitant rise in metabolism in the tissues of the leg since heat speeds up chemical reactions. As before if the metabolic demand for oxygen is not satisfied by the blood supply available gangrene ensues. However when the leg is packed in ice so that a temperature of 5° C is maintained chemical reactions are slowed down with a resulting marked decrease in the demand for oxygen.⁴

Thus when the leg is packed in ice a tourniquet may be kept in place for six hours or even longer and an amputation done at any site of election below the point of application. But if the tourniquet has been left in place for as long as eighteen hours an amputation must be done at the site of application.⁴

Prevention of Infection—It has been shown by McElvenny that in fresh wounds such as found in traumatic amputation of the leg in which hemorrhage has been controlled by clamp or ligature the early application of ice without the use of a tourniquet prevents infection and necrosis of the wound. In this way a patient who is in poor condition may gain a number of hours in which he may be prepared for operation without jeopardizing the possibility of either amputation at a site of election or primary closure of the amputation wound.⁹

Analgesia and Anesthesia—The use of ice and a tourniquet as a mean of analgesia or for the production of anesthesia is also of considerable importance. In thin extremities anesthesia of the sciatic nerve may be obtained in one to five hours when a tourniquet is applied to the thigh and the leg is packed in ice up to or slightly above the level of the tourniquet. While the cooling process is taking place pain is relieved and the patient may be transferred to another location for operation. Amputation may be done on an average of three

hours after the application of the ice without further sedation or anesthesia. Section of the sciatic nerve under these circumstances should not provoke pain.

Prevention of Thrombosis—It is also noteworthy that no clotting of blood has been found to occur in the vessels occluded by a tourniquet when the limb has been packed in ice. This has considerable bearing on the treatment of injured blood vessels in which thrombosis so frequently occurs when the attempt at suturing of vessel walls is made. Holman recommends the use of ice packs and a tourniquet about the leg preoperatively and heparin intravenously for at least the first twenty-four hours postoperatively when primary closure of a lacerated artery is attempted.²

SUMMARY

Amputations have been broadly classified under two headings: emergency and elective.

The indications for amputation have been enumerated under each of these headings.

The general and special principles involved in the various amputations of both upper and lower extremities have been discussed. Among these emphasis has been placed on the maintenance of an attitude of extreme conservatism with respect to the management of hand injuries, the restoration of maximum function of the damaged part, and gentleness in the handling of tissues in the procedures mentioned.

Attention has been called to some of the recent developments in general surgery which have special application to the field of amputations. The most important of these are the use of the sulfonamide drugs in wounds and the relationship between local tissue metabolism and the local blood supply. This last has been shown to be the rationale for the present-day use of the refrigeration method in the treatment of injured extremities.

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TRAUMATIC WOUNDS OF THE ABDOMEN

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and

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ABDOMINAL injuries have for long been of vital concern to man. Although not looked upon as being so quickly fatal as those of the thorax, they have always been associated with a very high mortality. Most patients are aware of this. The number and extent of such wounds have in large part been caused by man's machines. Today more than ever before we are dependent upon these machines in our daily activity, be it civil or military. As activity is increased (in either group) traumatic wounds of all kinds are likely to increase. We should expect therefore to see more abdominal injuries in our civil and military population with increased prosecution of the war. Because the nature of these injuries and their treatment are changing, we propose to discuss briefly in this paper wounds of the abdominal wall, stomach, duodenum, small bowel, large bowel, liver, pancreas and spleen.

Patients with abdominal injuries require the immediate attention and uninterrupted observation of the surgeon who must evaluate their status from all possible angles. The shorter the lapse of time between injury and examination, the more probable is an early, accurate diagnosis. Treatment may be embarked upon and carried out efficiently when a diagnosis is established. The penetrating and nonpenetrating wounds of the abdomen demand immediate operation. Intra abdominal trauma without visible wounds of the abdominal wall consti-

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tutes a real problem in diagnosis and frequently requires a period of observation. Surgical shock is present in most of these patients in varying degree, if not pronounced, measures should be instituted to prevent its further development and if marked it should be treated by wholehearted means.

GENERAL MEASURES

On reception patients should have all clothing removed placed in bed between blankets with external heat to keep them warm. Pain is best relieved by morphine sulfate (0.015 gm.) or dilaudid (0.002 gm.) hypodermically. Keeping in mind that such medication may alter diagnostic abdominal signs. If there has been evident *hemorrhage*, transfusion of whole blood should be given as soon as possible. Oxygen is indicated if *pallor*, *cyanosis* or other evidence of hypoxemia is present.

In the presence of *shock* without hemorrhage blood plasma is preferable although serum may be used. Because these may not be immediately available, normal saline or Ringer's solution given intravenously will bolster the failing circulation. In addition human serum albumin in small amounts (30 to 50 cc.) intravenously increases osmotic pressure of the blood. Special attention is directed, in the administration of blood and blood substitutes to the importance of employing adequate amounts of the material used and this is particularly significant in the use of plasma. For a patient of 15 pounds in moderate to severe shock the following amounts may be used:

Blood	1000-6000 cc per 24 hours
Plasma	500-2000 cc per 24 hours
Serum	500-2000 cc per 24 hours
Serum albumin	100-200 cc per 24 hours

Saline and glucose solutions may further dilute the blood constituents when they are already far below normal physiological levels. Therefore when plasma and serum are being used one must exercise judgment and discretion in giving crystalloid solutions or the recovery from shock may be interfered with. Under these circumstances crystalloid solutions should be given slowly and in limited amounts.

Stimulants may be useful and should be given when circulatory collapse is present or impending and other measures have not been effectual. The following substances all given hypodermically have been satisfactory: caffeine sodium benzoate 0.5 gm. adrenalin 0.5 cc. pitressin 1 cc. adrenal cortical hormone 1 cc.

Indicated operations should be undertaken as soon as the condition of the patient permits. They should be done efficiently and as quickly as is compatible with the required procedures. *Anesthesia* is selected according to the case at hand. Much can and should be done under local novocain. Spinal anesthesia affords excellent relaxation for extensive intra abdominal operations but tends to accelerate a falling blood pressure. General inhalation anesthesia open ether in particular is preferred by many.

Important as the preceding measures are in the preoperative preparation there is still another that should not be overlooked. It deals with the *fear* of the conscious patient. The individual who has an external abdominal wound is usually aware of its possible seriousness. A few well chosen words that provide some information and encouragement will increase the subject's fortitude.

INJURIES TO THE ABDOMINAL WALL

Nonpenetrating Wounds

Complete division of the intestine or rupture of a solid organ may be caused by an injury which leaves no mark upon the abdominal wall. This is usually due to a blow by a smooth blunt object.

In this war there has occurred a new type of injury the so called *blast*. This has been seen in England¹ more often than penetrating lesions. The abdominal viscera appear less sensitive to blast than the lung. A particular type is the immersion blast which takes place where men are caught in the water during the detonation of torpedoes or depth bombs. In case of bombing in this country we may expect more blast injuries in addition to those caused by crushing trauma and flying glass.

Acute abdominal conditions can be simulated by *hemorrhage into or beneath the rectus muscle*²³. This may occur in

the upper abdomen and be confused with an acutely inflamed gallbladder or in the lower abdomen and lead one to suspect an ovarian cyst. Before a hematoma forms, the usual diagnosis made is acute appendicitis particularly when the symptoms and signs appear in the right lower quadrant.

This hematoma results from the rupture of a rectus muscle with consequent tearing of the artery or vein. It has been seen in young healthy adults even soldiers following violent effort as leaping a ditch or onto a horse. It also occurs in young adults following hyalineization of the rectus muscle in typhoid fever or influenza. Pregnant women following coughing or sneezing occasionally rupture the rectus muscle and at times it is seen in elderly women without apparent cause. The hematoma causes swelling which is limited to the rectus sheath and does not pass the median line or lateral border of the rectus muscle. An operation is usually necessary to establish the diagnosis. The removal of the blood clot and ligation of any bleeding vessels hasten recovery.

Penetrating Wounds

Penetrating wounds of the abdominal wall offer a new problem in each case. Although not usually serious in themselves they may be associated with intra abdominal injury or lead to a virulent infection. Treatment cannot be standardized and must depend upon the time since injury, the condition of the patient and the experience of the surgeon. All agree it is better to operate in the doubtful case. When the wounded person is first brought in, his general condition must be quickly and accurately appraised. Those with hemorrhage should be immediately operated upon in order to halt the bleeding while those in shock unaccompanied by hemorrhage do far better with supportive treatment before surgical measures are instituted.

Wounds should be exposed at the operating table under a good light all dressings and superficial foreign material removed then the entire abdomen including the flanks and pubic region washed with soap and water and shaved. After preparing the skin and applying sterile drapes a careful debridement of the entire wound is done. When it is not possible to do so by blood dissection or when one desires to

Various English authors report mortalities following injury to the stomach which vary with the position of the hospital and length of time elapsed between injury and operation Charles⁶ reported three deaths in three patients (100 per cent mortality) Walters and associates⁷ three deaths in nine cases (33 per cent) Lockwood and his co workers⁸ one death in four cases (25 per cent)

As in all emergency abdominal surgery the primary aim of a surgeon in these injuries is to save the patient's life Simple suture of a lesion if possible is the procedure of choice At times this cannot be done and because of extensive damage a gastric resection is necessary Gastro enterostomy is rarely indicated save to restore the continuity of the gastrointestinal tract after resection It is doubtful if a total gastrectomy will succeed and it should be attempted only as a last resort

WOUNDS OF THE DUODENUM

Few wounds of the duodenum are reported and recovery in these is exceptional It is important in the event of an abdominal injury that this portion of the intestinal tract be remembered and examined at times it may be necessary to incise the peritoneum and mobilize the duodenum for adequate inspection Because of its location near the vertebral column and its more or less fixed position the duodenum is peculiarly vulnerable to crushing injuries which force it against the unyielding vertebrae McGowan⁹ in 164 traumatic penetrating wounds of the abdomen found no injuries to the duodenum In World War I² only slightly over 1 per cent of intra abdominal wounds occurred to the duodenum although 80 per cent of these resulted in a fatality

Injury to the duodenum should be closed by plication where possible since a resection or anastomosis carries a prohibitive mortality

INJURIES OF THE SMALL INTESTINE

In the intestinal tract the number of bacteria increases at the lower levels and the impression is gained that injuries to the large bowel are more dangerous and carry a higher mortality than those of the small intestine This is not borne out by figures from the last war

The most important factor in the successful management of injuries of the small intestine is the finding and treatment of *all* openings. This requires a careful examination of the entire tract. Whether one starts at the cecum and goes up or at the ligament of Treitz and comes down is immaterial. The vital thing is not to spend twenty minutes repairing a lesion then after exploring further find it necessary to resect this portion of the bowel. Missed injuries have been a very prominent factor in the cause of death. McGowan⁹ in twenty seven cases of fatal gunshot wounds in which autopsy was done found that in fifteen or over half visceral lesions had been overlooked at the time of operation. Billings and Walking¹⁰ in forty nine deaths from gunshot wounds found at autopsy that in nine cases visceral lesions of one kind or another had been missed. Although this is not the time or place for procrastination exploration must be thorough.

With present methods of airplane transportation for sick and wounded Lovelace¹¹ warns against transportation at comparatively high altitudes of patients with penetrating wounds of the gastro intestinal tract. With high altitudes the gas in the intestine expands and may be forced through the openings carrying fecal material and thus increasing the danger of peritonitis. He suggests that suction drainage of the stomach and duodenum be employed in such cases.

Poer¹² has found 1476 cases in the literature in which perforation of the intestinal canal was caused by an injury which failed to cause a wound of the abdominal wall. The operative mortality in these cases was 60 per cent. Most of these injuries were due to a blow or kick in the abdomen. Industrial accidents with a blunt object such as an iron bar or piece of timber striking the abdomen accounted for many and others were caused by implements of transportation as the automobile train street car airplane or bicycle. During this war we may well expect to see this type of injury increased.

Intestine situated in an inguinal hernia may be ruptured by a blow upon the abdominal wall. Aird¹³ and Bruce¹⁴ report such cases. In these instances the force may be applied to any portion of the wall. After rupture the intestine may return within the abdominal cavity and give symptoms at some distance from the hernial site.

Certain hospitals have many patients with *gunshot* and *knife wounds* of the abdomen. Charity Hospital in New Orleans¹⁵ admitting 1299 patients with gunshot wounds of the abdomen over a period of thirty one years. The mortality in these penetrating wounds is dependent upon the weapon used. McGowan⁹ in 164 such wounds of the abdomen found in those in which a knife was used (100 cases) a mortality of 20 per cent. When a gun was resorted to (64 cases) the mortality was raised to 60 per cent. Here the three important factors are the degree of visceral damage, severity of hemorrhage and time from injury to surgical intervention.

All writers emphasize the importance of *hemorrhage* as a cause of death.^{9 10 15} Mason¹⁶ finds a 90 per cent mortality in those patients with a large hemorrhage while in those with a small hemorrhage it was only 30 per cent. In his series it must be remembered that blood was obtained with difficulty and in only two was a transfusion given. By the proper administration of blood the factor of hemorrhage can be largely controlled.

In dealing with multiple wounds due to birdshot it may be best to pursue an expectant course of treatment. Willis⁷ reports four cases in which the patients recovered without operation. These small openings in the intestine tend to seal themselves although at close range the shotgun causes profuse hemorrhage.

Prior to World War I men with gunshot wounds of the abdomen received in battle were not operated upon with a resultant mortality which Eastman⁸ in 983 cases found to be 77 per cent. During that war this policy was changed and in 890 cases in which operation was done there was a mortality of 59 per cent. In this latter group the diagnosis was established at operation while in the group which had no operation undoubtedly some are included in which no visceral perforation was present.

In the American Expeditionary Forces lesions of the small intestine amounted to 22 per cent of total abdominal wounds of these 23 per cent were in the jejunum and 71 per cent in the ileum multiple injuries being almost always present. Among all casualties with small intestinal injuries both with and without operation the mortality in those with wounds

of the jejunum was 78 per cent and in those with wounds of the ileum 73 per cent. Resection commonly resulted in a mortality 50 per cent higher than simple suture of the intestine. One must assume that patients in which a resection was necessary had a more extensive injury to the intestine and consequently greater soiling of the peritoneal cavity.

Wallace in reporting his experiences in the British Army in 965 cases found perforation of the small intestine in 365 (38 per cent) with a mortality of 70 per cent. He found in injuries of the ileum to be more serious than those of the jejunum and favored a lateral anastomosis rather than one done end to end. The percentage of deaths following injuries to the small bowel varies greatly depending upon the time since injury and the distance transported before operation is done. Makins¹⁰ reports a mortality of 84 per cent in twenty five cases. Lockwood and his co-workers⁸ 42 per cent in fifty seven cases. Walters and associates⁷ 38 per cent of sixty four cases and Charles⁶ a 38 per cent mortality in twenty eight cases.

So far in this war Sir Gordon Gordon Taylor¹ finds a mortality of 53 per cent in wounds of the small gut. Although this shows no appreciable difference the more widespread use of the sulfonamides and blood plasma will no doubt greatly influence the final results.

Treatment in these injuries must be limited. Plication is done when feasible and resection only when absolutely necessary. At times resection may be avoided by a short circuit of the intestine.

INJURIES TO THE LARGE BOWEL

As one would expect injuries to the large intestine carry a high mortality. A large portion of this tract is retroperitoneal making it difficult to find all perforations and these openings give rise to a particularly virulent retroperitoneal cellulitis. Although the splenic and hepatic flexures are difficult to repair or even to examine exploration should start at the ileocecal valve and include the entire large bowel.

Wallace in 1200 cases in the British Army during World War I found that lesions of the colon accounted for 20 per cent of all abdominal injuries and when uncomplicated by

of the liver is feasible in certain cases. However care must be exercised not to cause further liver damage. Detached or devitalized fragments of the liver should be removed. Packing of the liver wound and drainage of the area has been it is generally agreed the most satisfactory means of treatment. The removal of packing is often associated with severe hemorrhage. Great caution should be exercised in this procedure delaying its removal as long as possible (seven to fourteen days) and providing for immediate transfusion in case hemorrhage occurs.

Various reports in this country from the civil population estimate the mortality rate for patients treated by operation at from 40 to 60 per cent (Kreig and O'Neil¹). The reviews based upon postmortem material suggest that the mortality rate is higher because many patients die before a diagnosis is made or any attempt at treatment can be instituted. The reported mortality of the American Expeditionary Forces of World War I was 6.27 per cent in liver injuries.

In the treatment of war injuries the problem of removal of *foreign bodies* including bullets and bits of clothing from the substance of the liver frequently arises. If adequate facilities are at hand for the maintenance of satisfactory blood volume it is probably better to remove such fragments at the time of exploration because it can then be done with less damage to the liver than at any other time. The formation of an external sinus that drains bile and infected material invariably occurs if a contaminated foreign body is present. If the unperitonealized portion of the liver is the site of the foreign body it is probably better to approach this directly through the chest at a later operation than to transect undamaged liver tissue in an effort to remove it through the anterior approach. The association of other intra abdominal injuries is not as frequent in the explosion or compression type of injury of the liver as in those instances in which it is due to projectiles. The treatment of the patient's general condition, the replacement of blood and the drainage of bile from the injured surface offer a means of saving many of these patients.

WOUNDS OF THE SPLEEN

Contusions falls and blasts as well as direct blows may produce rupture or fragmentation of the spleen. These and wounds due to knives and missiles frequently result in an exsanguinating hemorrhage which may be the cause of death. If there has been a complete tear of the spleen or if large vessels are partially or completely divided the hemorrhage is immediate. If the splenic capsule alone remains intact a large hematoma may form to rupture later. Sometimes fairly large wounds undergo cessation of bleeding with the onset of shock but later (days or weeks) suddenly have a secondary hemorrhage of serious extent.

The most reliable signs of splenic injury are the evidence of severe hemorrhage that is not otherwise accounted for and the presence of *hemoperitoneum*, although this is not easily recognized. In penetrating wounds of the abdomen the location of the wound may be suggestive. The presence of a mass in the left upper quadrant and pain referred to the left shoulder are significant if present but are not required to satisfy the diagnosis of injury to the spleen.

Before operation is begun on those patients who have had extensive hemorrhage provision should be made for transfusion during the operation because large tears in the spleen or pedicle that have ceased to bleed may bleed just as profusely again upon dislodgment of the occluding clot when the abdomen is opened or the spleen molested in the slightest. A patient under anesthesia can in a few minutes lose a large amount of blood. It is therefore advisable to secure the splenic pedicle of such a patient or better still to secure the vessels that make up this pedicle at the very tail of the pancreas making pressure on these to control hemorrhage until the field of operation can be cleaned of blood and clots and the extent of the injury determined. Except for very minor wounds suture of the spleen should not be attempted but rather removal of the entire organ.

Postoperative thrombophlebitis extending from the splenic pedicle has been described by Wilkie²² as a factor in postoperative mortality. Heparin and dicoumarin may be used to prevent it. Frequently there are injuries involving the adjacent organs specifically the colon stomach small bowel

or kidney when there has been a penetrating wound to the spleen

In general it may be said that the results of the surgical treatment of the injured spleen have been better in the non-penetrating than in the penetrating abdominal wounds. In the splenic injuries of the American Expeditionary Forces of the last war splenectomy was credited with a mortality of almost 100 per cent.

WOUNDS OF THE PANCREAS

Persons with wounds of the pancreas usually do not survive long enough to reach a hospital. In World War I less than 0.7 per cent of the wounded treated had injuries to the pancreas. The position of this organ renders it particularly vulnerable to blows above the umbilicus which crush it against the vertebral column. The friability of the pancreas facilitates the escape of its external secretions when it is traumatized. This leads to severe cellular reactions in the surrounding tissue.

If the pancreas is divided by a severe blow or penetrating missile there follows entrance of the external secretions of the pancreas into the lesser peritoneal sac and sometimes the general peritoneal cavity. Such accidents are accompanied by severe abdominal pain, the manifestations of peritoneal irritation and shock. Immediate operation is indicated and should include the removal of any devitalized portion of the pancreas and ligation of the divided ducts. Fragmented portions of the pancreas should always be removed. Because of its anatomical relations it is likely that damage to the pancreas is usually associated with partial to complete division of adjacent large vessels, the portal vein, inferior vena cava or even the aorta, any one of which could result in an immediate fatal hemorrhage.

Because only a small amount of pancreas near the head is essential, most of the organ can be sacrificed and the duodenum repaired in an attempt to save the patient. When extensive procedures have been carried out on the injured pancreas or if there are additional abdominal injuries, the abdominal wound should be closed with through and through unabsorbable suture material and the region of the pancreas

drained. If an injury to the pancreas is suspected careful exploration should be carried out with direct visualization of the entire organ. To expose the pancreas two approaches may be used (1) through the gastrohepatic omentum or (2) through the gastrocolic omentum.

RETROPERITONEAL HEMORRHAGE

Extensive retroperitoneal hemorrhage may result from penetrating injuries or from blows due to falling explosions impacts from falling debris and collisions. A hematoma may develop quickly in the retroperitoneal area when a large vessel is injured or it may form so slowly that it escapes notice until several hours after the accident or even after an operation upon the abdominal contents for an associated injury. If the hematoma is the presenting lesion the signs it produces are rarely clear-cut enough to differentiate it from intra peritoneal injury with certainty. Often there are signs of shock, pallor, perspiration, rapid pulse and lowered blood pressure without marked prostration. Various degrees of abdominal discomfort may be present with fleeting and inconstant abdominal tenderness and resistance. If there has been blood extravasation about many of the sympathetic trunks and ganglia there is a blush to the lower trunks and extremities. Certain English observers have emphasized that a semi-erection of the penis is often seen in extensive retroperitoneal hemorrhage and look upon it as a grave prognostic sign.

Conservative measures are adequate for the less severe cases if intra abdominal injury can be ruled out but this is sometimes impossible. If there is evidence of extension of the process exploration and an attempt at ligation of the bleeding vessels are indicated. In penetrating wounds with fragments of shells or other foreign bodies lodged deeply and firmly great care is required not to dislodge them during exploration if they produce occluding defects in large vessels that cannot be ligated.

CHEMOTHERAPY

There is no doubt in the minds of the authors that the use of sulfanilamide and related chemicals is beneficial in the control of infection in the surgery of abdominal injuries. The current literature is abundant concerning the use of these

various drugs. The evidence reported thus far does not justify the conclusion that these substances when used in reasonable amounts within the abdomen or abdominal wall materially interfere with normal healing. With the intra abdominal as with the local application of the drug and the maintenance of a therapeutic blood level we believe that extending infection in these parts can be prevented and controlled in the majority of instances—provided the degree of contamination is not too great. Its success or the success that we tend to attribute to it is dependent upon meticulous and complete debridement and the removal of all possible infected material, the functional restoration of continuity of the intestinal tract and the closure of wounds with minimal injury to tissues and without the production of local ischemia.

It should be borne in mind that although the incidence of serious systemic reactions to these drugs is low they do occur. Blood dyscrasias such as thrombocytopenia and agranulocytosis may result and end in death; consequently the blood picture must be watched. Furthermore, failure to maintain a proper water intake and output may be followed by renal complications and anuria which if uncorrected may be terminal.

Surgeons should consider that chemotherapy while beneficial in no way minimizes the quality and quantity of surgical therapy indicated but that it adds another possible hazard which requires additional care.

CONCLUSIONS

Abdominal injuries are usually serious. They may be divided roughly into penetrating and nonpenetrating wounds and intra abdominal trauma without visible wounds of the abdominal wall. All penetrating and nonpenetrating wounds require surgical exploration and debridement. All penetrating wounds require in addition careful systematic inspection of all viscera and the performance of the least possible surgical procedure compatible with saving life. Patients with intra abdominal trauma without visible wounds of the abdominal wall often require a period of observation for diagnosis and may or may not require operation.

Shock and hemorrhage commonly accompany all three

types of wounds and may be adequately treated by various measures but there remain the even greater problems of infection and postoperative complications. For the former we have chemotherapy of recent development and proved value. For the latter there remains unrelenting and meticulous postoperative care which includes the maintenance of blood constituents in proper amounts and fluid balance, the prevention of intestinal stasis and obstruction as well as the early recognition of the causes of elevated temperature such as intraperitoneal abscesses and wound infection.

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Shock and hemorrhage commonly accompany all three

THE TREATMENT OF BURNS

LESTER BREIDENBACH MD FACS

THE revival of interest in burns since the Pearl Harbor disaster where most of the casualties were complicated by burns has been tremendous. One seldom picks up a surgical journal without finding at least one article on burns. The treatment of the local condition is as varied as the colors in a kaleidoscope. With such a diversification of treatments it is difficult to believe that any one of them is completely adequate. All claim good results with the particular local treatment of the author. The important features of treatment are usually sidetracked or very casually mentioned, great emphasis being placed on the local application of some antiseptic or eschar producing substance.

Moorhead¹ defines a burn as an infected wound produced by heat. We do not, however, consider a compound fracture to be an infected wound until the 'six golden hours' have elapsed. Before this time it is considered to be a contaminated wound. The bacteria have not yet made inroads and are only on the surface of the wound. After six hours the wound is assumed to be definitely infected. Following the same line of reasoning, could we not properly consider the burn as only a contaminated wound² up to six hours?

In the reports on the Pearl Harbor casualties the 'six golden hours' were extended to much more than this by the local application of the sulfonamide drugs as first aid treatment. Many of the wounds so treated were compound wounds yet in spite of the fact that they could not be surgically treated for many more than six hours they still were only contaminated because of the bactericidal activity of the sulfa drugs. It was still deemed advisable, however, to debride the wounds thoroughly.

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EARLY TREATMENT

The *local treatment* of burns must begin at the site of accident if infection is to be minimized. This is especially necessary if there is likely to be a delay in surgical treatment as a result of transportation or other factors. At present the best preparation for immediate local use is a 3 per cent solution of sulfadiazine in 8 per cent triethanolamine (Pickrell⁴) which not only serves to prevent infection but forms a thin eschar which temporarily prevents loss of plasma. Where this preparation is not available the simple application of dry sterile gauze is the best preventative of further contamination.

Simultaneously the first aid treatment for primary shock must be vigorously carried out by the use of a liberal dose of morphine and measures to conserve body heat.

On the patient's arrival at the hospital or first surgical station a carefully planned *debridement and surgical cleansing* of the entire area of the burn must be done. This part of the treatment is of the utmost importance. It prevents infection thus avoiding the complication which accounts for most of the later deaths. Convalescence is shortened by more than 50 per cent where this procedure is properly and adequately carried out.

The patient is placed on a sterile sheet after all clothing, blankets and dressings have been removed.⁵ The surgeon has scrubbed and applied cap, mask, sterile gown and gloves. All dead skin and tissue are deliberately excised using forceps, scissors and scalpel. As each new part is approached clean gloves and instruments are used. Where the burn is extensive a team of several surgeons may each work on a separate part in order to shorten this period. Flasks containing several gallons of saline solution are available for washing the burned surfaces in order to remove all evidence of gross and microscopic dirt. When this has been properly, adequately and thoroughly accomplished the patient is transferred to a fresh bed with sterile sheet. A tent is erected with thermostatic regulation of heat at 85 to 88° F. The last part of the local treatment is started.

A discussion of the treatment of burns requires a study of the general treatment of the patient and the local treatment of the wound.

GENERAL TREATMENT

The general treatment of burns must include the following phases

- 1 Treatment of primary shock
- 2 Treatment of secondary shock
- 3 Replacement of lost fluids
- 4 Prevention of infection and toxemia
- 5 Measures to promote healing and combat infection

1 Treatment of Primary Shock

The primary shock from burns is similar to the primary surgical shock that occurs with any other severe trauma and requires first aid treatment. Profound surgical shock is irreversible and usually ends in death with any method of treatment known today. When shock has not reached this irreversible level treatment for it should be given simultaneously with the local treatment. In the ideal set up in a hospital a shock team busies itself on the patient while the surgical team works on the burned area. Morphine is given in adequate doses and acts in a twofold manner—to allay the shock and to induce an analgesia that permits of proper debridement. If the morphine does not give sufficient analgesia then a general anesthetic preferably cyclopropane is indicated.

2 Treatment of Secondary Shock

Secondary shock is the next important death dealing complication. This can be easily combated by careful and frequent observation of the patient to determine the loss in blood volume and by replacement of this loss at the same time correcting as rapidly as possible the continued loss of other body fluids whether it be through vomiting or in exudates at the burned area.

3 Replacement of Lost Fluid

The intravenous use of crystalloid solution is not completely contraindicated but it must be used in amounts that will not cause a washing out of protein or pulmonary edema. A good rule is to give intravenous normal saline in quantities sufficient to cause the patient to void 600 cc of urine daily with a specific gravity of 1.020 or less. Glucose may be added to the saline solution to help prevent damage to the liver.

As burns are accompanied by an increased blood concentration and low protein content of the plasma the ideal replacement agent is *plasma*. Plasma has the distinct advantage of greater availability than whole blood and unfavorable reaction from it occur in less than 1 per cent of cases in which it is used.⁶ The amount of plasma necessary to rebalance the patient can be calculated in various ways. The most accurate is probably the method of Ellington, Wolff and Lee⁷ which requires a hematocrit reading and a plasma protein determination then a calculation by formula or the use of a chart. There are two simple methods which suffice. (1) Black's⁸ hemoglobin method. Using a normal hemoglobin of 100 per cent and a blood volume of 5 liters of which 3 are plasma

$$\frac{\text{Hb}}{\text{Hb}_1} = \frac{\text{BV}_1}{\text{BV}} \quad \text{or} \quad \frac{\text{Hb}}{100} = \frac{5}{5-x}$$

where Hb is the observed hemoglobin value after the burn and x the amount of plasma lost. Here only a hemoglobin determination is necessary.

(2) Harkins' method is also simple to calculate requiring only a hematocrit reading. He gives 100 cc of plasma for every point the hematocrit is above 45.

Serum loss from the burned surfaces constitutes another hazard. Every effort must be made to minimize this loss by proper local treatment. Serum infusions should be given.

At this point in the treatment the patient is transferred to a tent whose temperature is carefully regulated to 88° F, this being the most comfortable temperature and one that does not cause peripheral vasodilatation.

4. Prevention of Infection and Toxemia

After Davidson¹⁰ introduced the use of tannic acid in burns the mortality on the children's surgical service at Bellevue Hospital dropped from 37 per cent to 14.9 per cent.¹¹ The coagulation methods which Davidson introduced became widespread and justly so because the resulting decrease in loss of fluids, the lessened pain and the simplified method for dressings all helped to decrease the mortality. However infection beneath the eschar became a common complication. In my opinion this occurred because the coagulum was ap

plied to the burned area without the initial surgical cleansing. The eschar had to be excised because of the presence of fever and toxemia. With the removal of the eschar there were two factors facing the surgeon (1) infection very often severe and leading to disaster and (2) the loss of fluids again, from the denuded area.

To prevent infection under the eschar various medications were added to the tannic acid such as 1 per cent gentian violet and 10 per cent silver nitrate. Then came the aniline dyes and their mixtures. They are coagulant, analgesic and antiseptic. Gentian violet became popular in 1 per cent solution. It was even advocated that previous debridement was not necessary. Then the triple dye combination was advocated by Aldrich¹² modified to contain 1 per cent gentian violet, 1 per cent brilliant green and 0.5 per cent neutral acriflavine. Pickrell¹⁴ described the sulfadiazine spray in triethanolamine, which was used every hour the first day, every two hours the second day, every three hours the third day and so on.

It is definitely my opinion that while all of these agents for local application are helpful when properly applied, none kills all organisms and renders the burned area completely clean by its antiseptic properties when it is applied to an obviously infected field. The importance of adequate and proper debridement of the area before the application of a local agent is clear. If this surgical cleansing is carried out diligently, infection in burns is minimized and quicker healing, less toxicity and the absence of the secondary period of fluid loss results.

5. Measures to Promote Healing and Combat Infection

The last phase of treatment consists of measures to promote the rapid repair of the burned area in order to prevent contracture and restore function as quickly as possible. Plasma loss is still an important factor at this point, since the raw granulating areas still secrete large amounts of fluid. *Azochloramide* dressings are the least irritating of all dressings to the tissue and they help to remove the slough and clean up infection if present. To make them a 1:500 solution of azochloramide in thiacetone is applied evenly on gauze. The impregnated dressings are now placed over the wounds, then

covered with several layers of sheet wadding and bandaged in place with pressure evenly applied. At times a plaster cast is applied instead of a bandage. This method besides cleaning up the infection also prevents the granulations from becoming edematous and prevents exuberance by decreasing the venous and lymphatic flow.³ The dressing is removed in a week to ten days. Hypertonic saline solution is now applied for twenty-four hours to wash off all azochloramide.

After this preparation of the granulations pinch grafts are applied and usually the pinch is a small deep graft. The skin grafting is done under local anesthesia and usually results in a very large percentage of takes.

Illustrative Cases

CASE I—G. V. a housewife aged forty-five years was admitted to Bellevue Hospital on February 26, 1942. She had set fire to her bed clothing while smoking. She was suffering from extensive burns all of second and third degree involving 65 per cent of the body surface. An inadequate surgical cleansing was done on the emergency ward. A 3 per cent sulfadiazine spray was applied in the usual fashion and the patient's temperature remained normal for forty-eight hours. At the end of thirty-six hours the eschar from the sulfadiazine spray was not forming rapidly enough and a triple dye spray was started. The patient was in secondary shock. Infusions and plasma were begun. On the third day the intake by vein and mouth was 7230 cc of fluids (1750 cc of plasma) with an output of 800 cc. The specific gravity of the urine was 1.026.

The patient's temperature now began to rise. During the period when sulfadiazine was applied its bactericidal properties had prevented infection. When the triple dye was substituted it gave a better eschar but since proper debridement was not done infection took place and until the death of this patient her temperature varied between 102° and 103° F. The output of urine was kept to over 1000 cc. with a specific gravity of 1.020 to 1.024. Serum protein on March 6, 1942 dropped to 4.9 mg. non-protein nitrogen to 30 mg. and sodium chloride to 434 mg. per 100 cc.

Because of the persistence of fever and the toxic condition due to absorption from this large area under the eschar on March 22 all eschar was removed and a sulfadiazine spray again applied. The temperature dropped to 99° F. for forty-eight

hours then gradually rose to 101 and then to 103 near which point it fluctuated until the patient's death on March 25. On March 20 the serum protein was 6.1 mg and the nonprotein nitrogen 28 mg per 100 cc and its output remained above 900 cc. The urine had a specific gravity of 1.024 excepting after the use for three days of sulfadiazine spray. For example beginning with the second spray after excision of the eschar the urinary output on three successive days fell to 150 cc, 200 cc and 250 cc respectively. At this time the sulfadiazine level was 15 mg per 100 cc of blood.

Because absorption from this large granulating area was rapid and extensive the spray was stopped and the urinary output improved. The fluid loss from the large granulating area was tremendous but with almost daily plasma infusions the serum protein never fell below 4.18 mg per 100 cc. The nonprotein nitrogen remained at 31 to 33 mg per 100 cc. The hematocrit reading ranged from 27.5 to 41 per cent. The severe toxic absorption from this large granulating area was our problem here as the patient never showed a serious disturbance of the blood chemistry. Nevertheless she continued to fail. As a last resort the entire burned area of the body was dressed with sterile gauze compression was applied with sterile candy cotton and then a huge plaster cast was put on over this—but to no avail. Autopsy showed extensive second and third degree burns, submucosal gastro intestinal hemorrhages, subacute septic spleen and severe fatty changes in the liver.

This case brings out several important points in the management of burns. Once the infection had taken hold under the eschar no amount or variety of treatment seemed to help when such an extensive area was involved. If proper and adequate surgical cleansing had been carried out originally this infection could have been minimized. Without this precaution sulfadiazine only inhibited the infection for short periods and then the brake was off. Again because of the infection the eschar had to be removed for drainage and fluid loss was tremendous necessitating almost continuous administration of saline solution and plasma intravenously. Finally it was demonstrated here that when sulfadiazine is applied locally over a large area a high blood concentration of the drug—15 mg per 100 cc—with suppression of urine in already overworked kidneys can result.

CASE II—Contrasting with Case I is that of a two and a half year old child who was admitted to the Beth David Hospital on October 5 1942 with second degree burns over 60 per cent of the body. The child was admitted one hour after the accident with no previous treatment. He was placed on a sterile sheet and under aseptic precautions a deliberate surgical cleansing was accomplished with soap water and large amounts of saline all dead skin was excised. The 3 per cent sulfadiazine spray was then applied every hour on the first day every two hours on the second day and so on until the fourth day when the eschar was well formed. No further local treatment was necessary. A temperature of 100.6 F was reached during the first twenty four hours but thereafter it remained normal. The eschar was entirely off at the end of three weeks with complete healing of the skin.

Debridement or surgical cleansing made the difference in the outcome and end result in these two patients.

COMMENT

Local Treatment

At Bellevue Hospital in the past two and one half years the triple dye has been used extensively in burn wounds but surgical cleansing has not been meticulously carried out. Most of the wounds showed evidence of infection. Those which were carefully cleansed and then had the triple dye applied responded favorably. At the Misericordia Hospital where the burn wounds were not cleansed adequately the local treatment consisted of applications of tannic acid and 10 per cent silver nitrate. Again they were all infected. When the eschar had to be removed for drainage the patient was back to the point where he would have been without the original local treatment. The infection and loss of fluid from the granulating surface made the condition of the patient very precarious.

Peripheral Vasoconstricting Agents

CASE III—An elderly male eighty five years of age was admitted to the hospital after receiving second degree burns of the face neck and both hands. A careful surgical cleansing was done and a boric acid (5 per cent) wet dressing was applied to the cleansed burned areas. At the suggestion of Dr. S. G. Berkaw he

was given stilbestrol 75 mg daily intramuscularly for ten days. The wounds did not become infected the temperature never rose above 99 F.

The rationale of *stilbestrol* treatment is based on the fact that *stilbestrol* causes vasoconstriction. With peripheral vasoconstriction the seepage of fluid from the burned area is decreased considerably. So far three cases have been treated with *stilbestrol* in large doses as an adjunct and no coagulating medication was added locally. In each case the surface of the burn formed a thin film with complete absence of secretion and rapid healing. The method is worthy of further trial.

We treated three other patients with second degree burns of the hands and feet by another method for vasoconstriction of the peripheral vessels suggested by Dr Berkow namely the use of *tobacco smoke*. The hand or foot was encircled in a Bunyon envelope made of cellophane and a clay pipe containing tobacco had attached to its stem a bulb and rubber tubing. The end of the rubber tubing was put into the envelope. By pressing the bulb smoke was forced from the free end of the rubber tube inside the envelope. The envelope was thus kept full of tobacco smoke. The burned area did not lose any fluid it formed a thin transparent eschar and healing took place rapidly. This method was not tried in extensive burns.

Both the *stilbestrol* and tobacco smoke methods are being tried on a larger scale experimentally in order to evaluate these substances as peripheral vasoconstricting agents to be used as adjuncts in preventing further loss of fluid from the denuded areas.

Army and Navy Experience

At Pearl Harbor the casualties consisted of large numbers of burns. The Army treated their burns under the supervision of Dr J J Moorhead who used the so called Carrel Dakin method in which after the burned extremity was incorporated in dressings and Dakin tubes inserted in the dressings irrigation was carried out using saline solution. The wounds did well and infection was minimized. The Navy on the

other hand used tannic acid jelly and solution gentian violet and the triple dye with or without silver nitrate. In different parts of the Navy the treatment varies. Aboard ship the early debridement of burned areas is not favored. It is claimed that debridement is a long tedious procedure and is a great factor in production of shock. No attempt is made to debride for three to four days. I can hardly conceive of the value of debridement after three to four days because by that time infection is present and debridement will not help. It is only in a contaminated area that surgical cleansing is of value.

Local Sulfonamide Therapy

We passed through various phases in the local treatment of the burned area even before the introduction of the eschar producing substances in 1925. Following this came the dye period and modification of the tannic acid method. The dyes also form some eschar and the eschar is a real aid in decreasing the exudation of plasma and chlorides from the burned surface. None of these agents however are antiseptic enough to prevent or destroy infection. When the sulfonamide group of drugs was brought out it was hoped that at last an agent was at hand which would inhibit bacterial growth completely. Unfortunately there are obstacles not yet completely overcome which prevent the free use of these drugs on burned areas.

In the local application of the crystals of sulfanilamide or sulfathiazole without a wetting agent the drugs do not go into solution and in later dressings the caked crystals are found on the surface of the area. In this form the drug is inert and does not inhibit bacterial growth. Pickrell's 5 per cent sulfadiazine spray which employs a wetting agent exerts real bactericidal action but great care must be exercised in its use over a large area because of its rapid absorption and resulting high concentration in the blood. It makes an excellent first aid application before surgical cleansing can be done. Recently a preparation has been brought out consisting of a cellophane material impregnated with sulfanilamide rolled up like a bandage. The directions suggest application of this material to the burned area and the use of a pressure bandage over it but the directions also suggest changing the dressing

every twelve to twenty four hours as the sulfa drug dissolves out or the sheet containing the drug may disintegrate. This goes back to some of the older methods where changing the dressing daily was a ritual. The patient suffered untold pain and at times an anesthetic was necessary for the change. Changing the dressing also allows an excellent opportunity for reinfection of the wound.

Treatment of the Burn Wound as a Surgical Wound

Mason³ has very ably applied sensible surgical principles to burn treatment. Believing that burns are contaminated wounds and can be surgically cleansed he suggests the treatment of this wound after surgical cleansing is a clean wound in which one expects to obtain healing by primary intention. The method consists of thorough surgical cleansing then the application of a pressure dressing and in the case of extremities the addition of proper splints for immobilization. It follows the principles of Orr in the treatment of compound fractures. The pressure bandage and immobilization reduce the lymphatic circulation of the part to a standstill. There is no absorption there is a marked decrease in exudation from the surface. Infection is inhibited. As Mason³ states: "It is the principles that count in surgery and the burned area should therefore be treated by the same surgical principles as any other wound."

There have been some startling revelations in the Coconut Grove fire in Boston. Patients were brought into the hospital in such large numbers that surgical cleansing and debridement were attempted only in the first few cases. In subsequent cases the burned areas were not debrided but instead 10 per cent boric acid ointment was liberally applied and a huge *pressure dressing* was placed over this ointment. Primary and secondary shock was vigorously treated. No tent was required. The patients did exceptionally well and when the dressings were removed considerable healing had been accomplished and the granulating areas were clean and ready for skin grafting. The amount of infection was minimal.

In contrast to this treatment at another hospital in Boston debridement was attempted but because of its impracticality due to the large number of cases boric ointment was applied

but no pressure bandage was added. These wounds did not do nearly as well as the wounds at the first hospital where pressure bandages were applied. Most of the burned areas at the second hospital were infected and skin grafting had to be delayed for a considerable time.

Cannon and Cope⁸ have shown so beautifully in a recent article the rapid degeneration of epithelium treated with 10 per cent boric ointment in contrast to the delay in healing when using tannic acid with silver nitrate, gentian violet, triple dye, fibrinogen, triethanolamine, sulfadiazine, pectinates, scarlet red ointment and so forth.

The report from Boston and the work of Cannon and Cope seem definitely to stabilize our concepts of the local treatment of burns. In local treatment the simple boric ointment pressure dressing applied to a burn within a few hours of its inception tends to give the best results. It further simplifies the treatment so that it may be carried out under practically all conditions.

Scar Formation

The properly treated burn or ideally treated burn will heal promptly without sepsis and without scar formation. If the burn is deeper than second degree, scar formation will occur because it takes so long for epithelium to fill the area from the margins of the wound allowing in the interim marked fibrosis and scarring in the granulation tissues.

Skin Grafting

Just as soon as the granulation tissue of a burned area is ready, skin grafting should be done. The small deep grafts¹³ or pinch grafts are especially applicable to burns. They are easy to procure, they will take earlier on granulations than any other grafts and no general anesthetic is needed. The Padgett dermatome has made skin grafting over large areas more practical. The graft can be cut to the thickness of the deep pinch graft and on a properly prepared granulation surface usually takes well and gives a much better cosmetic result than the deep pinch graft.

CONCLUSIONS

1 Burns should be considered as surgical wounds which are contaminated up to the six hour period. If this surgical principle is correct then proper surgical cleansing is the ideal initial treatment upon arrival at the hospital.

2 If the six hour period must be prolonged because of conditions on the battlefield at sea or in the air then the best first aid dressing is sulfadiazine or possibly the new 'sulfafilm' (sulfanilamide incorporated in cellophane like tissue). These are bactericidal and allow a prolongation of the six hour period but surgical cleansing is still indicated as soon as possible.

3 The local application may be tannic acid, tannic acid with 10 per cent silver nitrate or the triple dye preparation. The patient should be placed in a burn tent preferably equipped with a thermostat to keep the temperature within the tent at 85° to 88° F. In lieu of the eschar or dye application the pressure bandaging of Mason is especially valuable on the extremities.

4 The general treatment must be simultaneously carried out as outlined for (1) initial shock and (2) secondary shock.

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TRAUMATIC PSYCHONEUROSES VERSUS ORGANIC INJURY

A Critical Analysis of Cases

IRVING PARDEE M D

It is the purpose of this study to report on a group of eighty-two patients observed in the neurological clinic of St. Luke's Hospital. From these observations certain conclusions are drawn concerning the relative frequency with which trauma will produce organic disease or functional nervous disorder in the form of the psychoneuroses i.e. will produce symptoms that are psychologically motivated. All cases which because of paucity of records precluded final deductions were omitted from this study. All diagnoses were made by me following the results of a complete and exhaustive study.

There were numerous types of injury responsible for the nervous disorders of the patients in this series. Fifty-two were cases of head trauma, the minority of which were actual fractures of the skull. The next largest group was composed of nineteen cases of injury resulting from falls, the part having suffered the brunt of the injury not being noted. Six patients had injuries to the limbs, six to the body and back, six had had operations, and three had been injured in war. Of the entire group, fifty-one presented clinical pictures that were clearly organic in origin, while forty-one had disorders which were definitely hysterical (psychogenic) in type. The large number of head injuries is of special note and forces a conclusion that trauma to the head has on the one hand a profound emotional effect in producing actual organic changes of an hemorrhagic nature as noted by Osato, and on the other hand a psychological effect based on fear of the potentially dangerous results which are supposed to and apparently do follow such injury, the hysterical reaction being

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heightened thereby Moleen also has hinted at this by his remark that a neurosis may be more readily brought about when violence is applied directly over the nerve centers as the vault of the skull or the spinal column and that the fall does not need to be so great for comparable results when the victim lands on his head Glaser and Anderson likewise note that head injury produces a sensitization favorable to psychoneurotic symptoms whether or not brain lesions are demonstrable

SYMPTOMS

Thirty five of the fifty two patients with head trauma suffered organic injury while thirteen had functional neuroses—a few cases being unclassified This is particularly of interest because many of the group with organic disturbances would previously have been considered as having functional disease however symptomatology and signs were such that a definite organic basis was predicated The *outstanding symptom* of these head injuries was headache occurring in thirty two of the total of fifty two cases twenty five of these being in the organic group dizziness occurred in fifteen cases evenly divided between the organic and functional injuries while personality changes and convulsions were associated with thirteen head injuries all of which were of the organic type except two which moreover were associated with marked personality changes

The *length of time between the accident and the development of symptoms* has been stressed by some as a differentiating point between organic and psychogenic types of trauma In my series however in the cases in which symptoms developed under six weeks I could only note a slight preponderance (ten to seven) in the organic group The number in which symptoms developed within six months was about equal in both groups but it is of note that incases manifesting themselves after six months the functional type shows a definite preponderance—nineteen to thirteen This is in accordance with previously accepted notions but does not at that remain as a valuable differentiating point

Moleen has said that *in the severe injuries* the symptoms follow promptly and are as follows giddiness throbbing headache anxious attitude disturbance of vision and a change

to a morose disposition. These symptoms are similar to those I have mentioned as being frequently caused by definite structural changes in the brain. It is of interest that in Osnato and Gilbert's paper on traumatic encephalitis a tabulation of symptoms showed a striking conformity with those that have been noted.

In my complete series of cases symptoms were present in the following order of frequency: headache, nervousness and apprehension, dizziness, tremor, local pains, change in personality, fatigue, numbness in the arms and legs, disturbance of sleep, depression, blurring or double vision, convulsive attacks, enfeebled memory, while fainting attacks, increased perspiration, restlessness, local paralysis, loss of sexual power, nausea and vomiting were of lesser importance.

More prominent in the patients with psychogenic neuroses were symptoms such as nervousness and anxiety, local pain in the legs, spine and head, fatigue, tremor and depression and troubled sleep. In fact, eleven out of a total of thirteen patients with local pain after falls had functional injury. These symptoms should ordinarily, therefore, be considered as associated with a psychoneurotic condition.

Moleen in discussing the symptomatology has emphasized the frequent prominence of *sympathetic symptoms* such as flushing, hot and cold sweats, rapid pulse, dilated pupils and intestinal disturbance with flatulence. These he says depend upon emotional disturbances incident to trauma, however many of these symptoms combined with fatigue, numbness and coldness in the extremities were present in both Osnato's cases and in my organic group. The close association of severe anxiety states with epidemic encephalitis presenting related vegetative nervous system symptoms, namely, the paroxysmal disorders of respiration, flushings, tachycardias and preconvulsive like episodes, is of importance in drawing similar conclusions in this group of cases. Many authors have noted the comparative vulnerability of the base of the brain and its coverings to trauma. Thus those vegetative centers which lie in the pons and medulla are a most favorable site for lesions and the hypothalamic region is likewise vulnerable.

These sympathetic symptoms are considered by some to be psychogenic (emotional) in origin and only further clinical

heightened thereby. Moleen also has hinted at this by his remark that a neurosis may be more readily brought about when violence is applied directly over the nerve centers as the vault of the skull or the spinal column and that the fall does not need to be so great for comparable results when the victim lands on his head. Glaser and Anderson likewise note that head injury produces a sensitization favorable to psychoneurotic symptoms whether or not brain lesions are demonstrable.

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Another patient who was admitted to the surgical clinic following a fall after a careful study by x ray was told that an injury to his knee and a broken neck were evident in the roentgenogram. He came to my clinic four years later complaining of severe pain in the neck and numbness in the left foot. Reexamination and another x ray picture combined with a study of the old plates definitely ruled out the supposed fracture of the fifth and sixth cervical vertebrae but physical examination revealed a complete left hemi anesthesia with a marked hysteroid attitude. A more cautious initial suggestion by the physician to this patient might have prevented him from becoming the victim of a chronic traumatic hysteria.

Careful neurological examination is important and must not be omitted in these cases. The observation of changes in reflexes, nystagmus, optic nerve pallor and sensory disorders is essential but these signs must be thoughtfully evaluated so as not to bring undue suggestion to the patient (Strauss and Savitsky). Spinal fluid and radiographic studies including pneumoencephalography may by their findings bring a previously diagnosed case of post traumatic hysteria into the group of organic injuries to the nervous system. On the other hand negative evidence may not be enough. A psychiatric study must be made of the underlying personality of the patient as it relates to the trauma and the mechanisms which lie back of the escape into the symptoms.

The literature of the traumatic psychoneuroses notes varying conceptions as to their etiology. First an organic basis was advanced then a psychogenic basis, and finally a sharper differentiation was made between the two types. The name traumatic neuroses was first given by Erichsen and Oppenheim in 1889 wrote a splendid treatise on the subject stressing the fact that the effect on the nervous system was through sudden vibration or by reflex action. Erichsen thought that all cases were due to concussion of the spinal cord. Erb, Westphal and Rieger following the lead of Oppenheim stressed the importance of molecular changes in the central nervous system. Page who had had a wide experience in railroad cases in England was the first to offer a psychic basis for the traumatic neuroses, and to recognize hysteria as a possible result of injury.

Pearce Bailey has consolidated much of the preceding data in his excellent book on injury to the nervous system and in a brief paper written shortly after its publication he brought out such a mass of incontrovertible evidence that the psychological mosaic of traumatic neuroses was firmly established. He noted especially the arousal of the emotions of fear, horror, anger and the desire for revenge as the result of injury. Contributing to this was the conscious working upon the emotions by a pernicious environment, namely, family, friends and lawyers, the suggestion of doctors and nurses by their examinations and ill advised sympathy. He also noted that those persons who were considered at the time of injury as having been fortunate in escaping unscathed or with slight injury were apt to be the later sufferers from a traumatic neurosis. As opposed to this was the immediate loss of function which usually follows organic nervous injury. The conclusion was reached that structural changes had not taken place in the hysteric patient with the longer interval between the accident and the onset of pronounced symptoms.

Many of the earlier writers drew inaccurate conclusions from their cases as exemplified by a case reported by Bailey as one of traumatic hysteria. Starr whose patient it was saw him after a railroad accident suffering from severe back pain. The patient was paralyzed for fifteen months, had retention of urine for eight months and numbness in the legs and back with atrophy of the muscles in the legs and thighs. Anesthesia was present around the anus, over the sacral saddle area on the buttocks and around the umbilicus. Later he moved his legs and one year later walked though anesthesia remained. Bailey considered this case to be the result of a cauda equina lesion and an astasia abasia. My belief is that the patient suffered only from a severe lesion of the cauda equina which resulted in his paralytic and anesthetic symptoms. As noted above a more accurate neurologic diagnosis in the light of modern technical advances applied to many of the cases reported in the older literature will remove them from the functional group of the traumatic neuroses. Wimmer brought out this important point by observing that the traumatic neuroses require the same impartial analysis of symptoms and causes as do the material consequences of

trauma and the treatment given in the pure hysteria must be approached on the basis of the physical and mental manifestations of an emotional shock.

The factor of *constitutional predisposition* is emphatically stressed by a group of recent authors on the subject. Barler quotes Bonhoeffer to that effect and Schroeder differentiates two types whom he calls the industrious and the lazy. The latter tend to avoid work and become antisocial, vagrant and alcoholic while the industrious by their interest continue at work despite injury. Moleen likewise notes the important factors of heredity and excitable and emotional temperaments in the formation of neuroses following injury. These tendencies are nurtured by the familial influences of the early formative years before adolescence. An influence exerted upon an innate neuropathic child by a neurotic, alcoholic or psychotic parent produces a serious psychologic deviation and trauma serves as a torch to light up a smoldering neurosis.

Coriat has expressed a psychoanalytical conception of this problem and can be considered as voicing an advanced viewpoint in favor of a functional basis for the traumatic neuroses. He says that the symptoms serve to neutralize or serve as an escape from the painful or terrifying situations of the accident. He considers the war neuroses and traumatic neuroses as identical though the underlying psychological mechanism of the war neuroses seem to me to be more simple and obvious. The factor of compensation does not enter into the acute war neuroses although it may in those which have persisted and have arisen since the war.

An early example of the recent tendency to consider the traumatic neuroses under the original structural injury concept of Oppenheim and other writers is that of Osnato and Gilberti whose paper on the postconcussion neuroses has given us striking data in opposition to the growing emphasis on the psychologic factors in their causation. They collected data on one hundred head injuries with concussion with a detailed analysis of the literature on concussion and some pathological material to prove that these patients have a traumatic encephalitis. A diffuse perivascular hemorrhagic infiltration is seen more especially involving the periphery of the brain with pia arachnoid extravasation as well. Secondary

degenerations are very rarely seen as permanent disabling clinical phenomena following concussion of the brain with or without fracture of the skull. They consider that the psychologic coloring is superadded as a result of later emotional and environmental influences. This material does not necessarily serve as a basis for classification of the group of cases herein presented but it does present a series of patients whose severe injuries resulted in a composite of symptoms not varying much from those noted in my study. Friedman and Strauss and others more lately have presented convincing evidence obtained by means of the newer diagnostic techniques that the organic structural change is present in a considerable group of patients following trauma.

TREATMENT

The attitude of the physician who first treats an accident case plays a vital role in its subsequent course. The neuropathic type of patient must be recognized on first examination and to him no adverse suggestion should be given; no speculation as to what might happen; no statement that he is lucky he did not get as severe an injury as this or that patient received in the same accident. He should be put to rest if possible away from patients with severe injuries away from friends, family, doctors who may be too solicitous and from lawyers.

That a *wish for compensation* is a fundamental mechanism behind traumatic hysteria must be granted but this does not cover the entire psychological problem. Compensation for work done is a rather late development in the phylogenetic scale of civilization and therefore is not a deeply submerged emotional reaction. Deeper in the emotional life are thwarted desires for ego domination with the antithetic feeling of inferiority. The hysterical personality is essentially an inferior one both from the medicopsychological viewpoint and from the patient's own self estimate. If he can obtain a better self esteem by being in object of sympathy and importance and finally compensated this rebuilds the ego and restores his own position in the world reintegrating him for another period of time. Whatever emotional repressions and conflicts in the realm of fear, anger and sex and whatever dis-

satisfactions in the social relationships and in work are also present should be considered as by products

It follows that the patient with traumatic hysteria must be studied as a whole personality in his relation to his heredity, his reaction to society throughout life and lastly his own individual problems associated with the trauma. When this study is completed we will have a psychological mosaic and individual background and pattern the case. With this information at hand it is the duty of the physician to acquaint the patient with the pattern of these emotional forces and how they have resulted in the presenting symptoms. He also will explain what those symptoms mean in the way of conversion mechanisms and how a realization of the true conflict will contribute toward his understanding of his illness and its relation to the injury. Such an understanding may reduce some of the distortion of the ego and allow a firmer concept of the amount of just compensation.

What should be the attitude of physicians toward compensation in these cases of traumatic neuroses? I believe that even though the patient is neuropathic before the accident the subsequent psychoneurosis is none the less compensable. Strauss and Savitsky also consider that the previous personality pattern of the patient has no bearing on the compensability of the accident. If all physically and nervously inferior people were excluded from work because of fear of trauma there would be very few people working or in fact riding on trains or subways or in automobiles. These neuropathic patients are sick (except in the rare cases of malingering) indirectly because of their inherited weakness but directly because of an accident and should be compensated. An early money settlement for the total amount of the damages should be encouraged. Weekly or monthly payments are not advisable being in fact exceedingly destructive to the morale. When payments are spread over a long period the patient is likely to acquire new symptoms through repeated medical examinations or through contact with other patients and there also may result a greater fixation of old symptoms. Following the lump sum settlement there should be no privilege of reopening the case. Idleness is extremely harmful to these patients and should be avoided. Work should be pro-

vided for them if possible in the same business and at the same salary even though the work is lighter (Strauss and Savitsky) This course if followed would be a constructive therapeutic approach to a solution of the vexing problems offered by the traumatic neuroses

COMMENT

Opinion today favors the grouping of the traumatic nervous disorders into two classes one composed of those with an organic structural basis and the other of those with a functional psychologic basis Improved diagnostic procedures in organic brain and cord lesions are constantly enabling us to reduce the number of our diagnoses of the latter in cases of trauma The disorders due to organic lesions should not be considered neuroses at all The traumatic hysterias however are just as definite an entity as the organic lesions and a careful psychological analysis in these cases will reveal conflicts and repressive tendencies sufficient to produce the picture presented

In between these two classes lies a mixed group in which there are structural changes with an added hysteroid reaction Many of these were seen in the first World War and for a time disturbed those of us with a preconceived notion that there was a fairly wide gulf between these groups of patients We now know that it is exceedingly common to see in encephalitis multiple sclerosis vascular disease of the brain and certain other diseases a marked hysteroid reaction and the same may be encountered in a traumatic disturbance of the central nervous system where it is superimposed upon and definitely colors the clinical picture

FRACTURES OF THE TIBIA AND FIBULA*

Treatment with the Stader Reduction and Fixation Splint

C M SHAAR MD FACS

FRANK P KREUZ Jr MD FACS†

and

DONALD T JONES MD‡

IN the treatment of fractures the fundamental principles are the bases of good results. It is not sufficient to know that the fracture is simple or compound, transverse or oblique, spiral or greenstick, impacted or comminuted, or whether it enters the joint, in addition an accurate appraisal of injury to soft tissues, especially the blood vessels and nerves, is imperative. The importance of x-ray examinations before and after reduction and during the period of follow up and the selection of the proper type of anesthesia for reduction cannot be over emphasized.

The various types of accepted treatment may be classified as

- 1 Open reduction and internal fixation
- 2 Skeletal traction
- 3 Plaster cast immobilization
- 4 External fixation

Objectives of Treatment

Fractures whether in civilian life or military service are not infrequently associated with other injuries, therefore the primary objective in treatment is first to save life, then limb.

The opinions or assertions contained herein are the private ones of the writers and are not to be construed as official or reflecting the views of the Navy Department or the naval service at large.

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COMMENT

Opinion today favors the grouping of the traumatic nervous disorders into two classes one composed of those with an organic structural basis and the other of those with a functional psychologic basis Improved diagnostic procedures in organic brain and cord lesions are constantly enabling us to reduce the number of our diagnoses of the latter in cases of trauma The disorders due to organic lesions should not be considered neuroses at all The traumatic hysterias however are just as definite an entity as the organic lesions and a careful psychological analysis in these cases will reveal conflicts and repressive tendencies sufficient to produce the picture presented

In between these two classes lies a mixed group in which there are structural changes with an added hysteroid reaction Many of these were seen in the first World War and for a time disturbed those of us with a preconceived notion that there was a fairly wide gulf between these groups of patients We now know that it is exceedingly common to see in encephalitis multiple sclerosis vascular disease of the brain and certain other diseases a marked hysteroid reaction and the same may be encountered in a traumatic disturbance of the central nervous system where it is superimposed upon and definitely colors the clinical picture

for external fixation. The Stader reduction and fixation splint has been in use at the Naval Hospital Philadelphia for over a year, during which period twenty-one fractures of the tibia have been treated by this method. The results have been more uniform and better than with any method we used in the past.

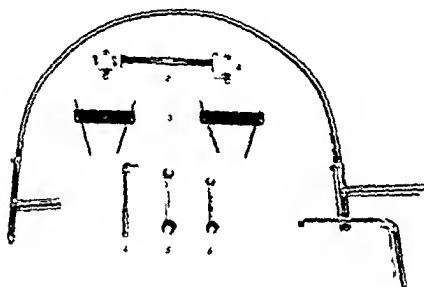


FIG. 136—Splint and instruments necessary for its application. 1 Flexible shaft drill. 2 Adjustable connecting bar assembly. 3 Half pin units. 4 Universal wrench for locking pins into pin bar. 5 and 6 Wrenches for locking of nuts and activating bar and screws.

CLASSIFICATION OF FRACTURES OF THE TIBIA AND FIBULA FROM THE STANDPOINT OF TREATMENT BY THE STADER REDUCTION AND FIXATION SPLINT

- A Acute fractures—Simple and compound
 - 1 Fractures with long proximal and long distal fragments
 - 2 Fractures with short proximal and long distal fractures
 - 3 Fractures with long proximal and short distal fragments
 - 4 Fractures with short proximal and short distal fragments
 - 5 Fractures with long proximal and comminuted distal fragments (no major distal fragment)
 - 6 Fractures with short proximal and comminuted distal fragment.
- B Compound fractures with osteomyelitis
- C Old ununited fractures with or without loss of bone
- D Old ununited fractures with chronic osteomyelitis
- E Old fractures with malunion

TECHNICAL CONSIDERATIONS IN THE VARIOUS TYPES OF ACUTE FRACTURE

FRACTURES WITH LONG PROXIMAL AND DISTAL FRAGMENTS

Fractures with long proximal and distal fragments comprise by far the great majority of fractures of the shaft of the tibia

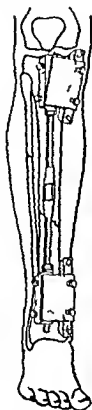


Fig 137



Fig 138

Fig 137—Regular tibia splint

Fig 138—Regular tibia splint applied

and require the use of the *regular tibial splint* (Figs 137 138)

Sites of Splint Placements

The site of election is on the *anteromedial surface* of the tibia. However, it may be necessary in certain circumstances

such as in wounds of the anterior surface to place the unit on the *anterolateral or medial surface*, as the case demands

Pin Placements

The first pin (pins are $\frac{3}{16}$ inch in diameter and 5 inches long) is inserted directly through the skin about two finger breadths from the upper end of the tibia just medial to the tibial tubercle. During the insertion of this first pin *the pin bar must be held parallel to the proximal fragment*, because the greater the dysparallelism between the pin bars and their corresponding fragments the greater the restriction of the reduction maneuvers (Fig. 139)

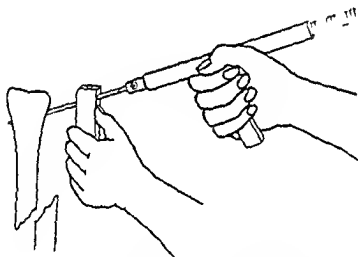


Fig. 139—The first pin is inserted with flexible shaft drill. Pin bar held parallel to the proximal fragment.

When inserting the second pin in the center of the shaft *the pin bar should be held about $\frac{1}{2}$ inch from the skin* so as to allow for any secondary swelling should it occur. The pins are then locked in the pin bar by means of the set screws (Fig. 140)

The third pin is now inserted in the distal fragment about two finger breadths from the lower end of the tibia just medial to the tibialis anticus tendon being certain again that the pin bar is held parallel to the distal fragment. Again when inserting the fourth pin the pin bar is held about $\frac{1}{2}$ inch from the skin and when applied properly *the pin bars will*

not only be parallel to their respective fragments but will be parallel to each other when the fragments are properly lined up

Application of the External Adjusting Assembly

The surgeon now grasps each pin bar and by hand corrects the minor displacement of the fragments *including the rotation* by bringing the *distal fragment in line with the proximal*. This can be readily ascertained by a line drawn from the anterior superior iliac spine through the center of the patella to the interval between the large and second toe. When in doubt compare the injured with the uninjured side.

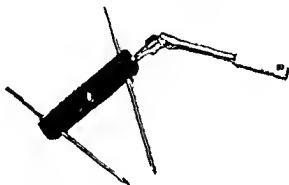


Fig. 140—Universal external adjusting assembly for locking pins into pin bars

While the surgeon holds the pin bars in their corrected positions an assistant applies the external adjusting apparatus as described previously.

Reduction of the Fracture

As stated above most of the major correction including the *rotational displacement* is corrected by hand before the adjusting assembly is connected to the pin bars. Complete reduction may now be performed or delayed for several days as the circumstances demand for example in transverse fractures associated with extensive soft tissue injury or in badly comminuted fractures immediate full extension may not be advisable and in cases of multiple casualties the time factor may not permit immediate individual reduction. In such

eases by a simple tightening of the screws and lock nuts the unit will act as a *rigid splint*, the secondary adjustments or reduction maneuvers being performed later often without the need of an anesthetic and with or without fluoroscopic control. The actual *reduction* afforded by the various adjusting screws has already been described.

In the reduction of the fracture it is well to keep in mind the following points:

1 Lateral displacements cannot be corrected before the shortening has been corrected.

2 Overextension damages the soft tissues and is dangerous. Because this mechanical splint with its powerful turnbuckle exerts such tremendous force with such ease we must become imbued with a spirit to *save the soft tissues* and *never use force*.

3 If at any time during the reduction maneuvers it seems to be necessary to use force *stop loosen* all adjusting screws and lock nuts and *start over again*.

4 If the limit of the adjustment reduction has been obtained without having achieved adequate reduction of the fragment it is best immediately to remove the improperly placed pin and reinsert it with the pin bar in the proper place.

5 Pins must be inserted through the opposite cortex.

Fluoroscopic and X ray Control for Pin Insertion and Reduction

The pins may be accurately inserted from cortex to cortex without the aid of the fluoroscope. It is usually easy to feel the pin go through each cortex. As a rule it is better to insert them a little too far because later they may be easily pulled back with the hand chuck if the check x ray films show them to be too far in.

It is also preferable as a general rule to guide one's reduction maneuvers by the anteroposterior and lateral x ray films rather than by the fluoroscope. One should train himself to visualize accurately not only the fracture displacement but also the mechanisms of the splint and the forces to be overcome in order to effect proper reduction of the displacement. The dangers of excessive irradiation to the surgeon are well known but not sufficiently acknowledged.

not only be parallel to their respective fragments but will be parallel to each other when the fragments are properly lined up.

Application of the External Adjusting Assembly

The surgeon now grasps each pin bar and by hand corrects the major displacement of the fragments *including the rotation* by bringing the *distal fragment in line with the proximal*. This can be readily ascertained by a line drawn from the anterior superior iliac spine through the center of the patella to the interval between the large and second toe. When in doubt compare the injured with the uninjured side.

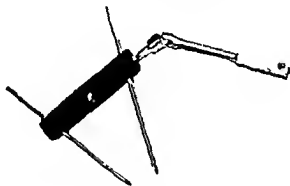


Fig. 140—Universal external locking pin into pin bar

While the surgeon holds the pin bars in their corrected positions, an assistant applies the external adjusting apparatus as described previously.

Reduction of the Fracture

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inserted in the anteromedial and anterolateral surfaces so as to avoid penetrating the extensor tendons or their sheaths and also to permit the splint to be applied to the anteromedial aspect of the leg. Before applying the right angled bar one should place it on the desired aspect of the leg and visualize

Fig 142

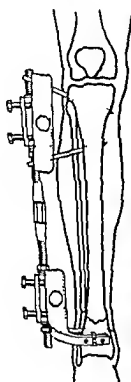


Fig 141

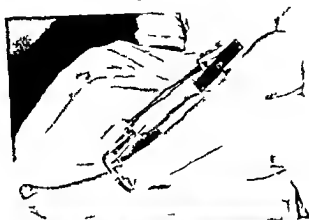


Fig 143

Fig 141—Special right angled splint for short fragment fracture

Fig 142—Right angled splint applied

Fig 143—Right angled pin bar unit applied to the os calcis in comminuted fracture of the distal end of the tibia

the position in relation to the splint as a whole. The bar portion of the right angled pin bar *must also be held parallel to the fragment during the insertion of the pins* and also parallel to the pin bar of the main fragment. This is necessary to obtain the maximum amount of reduction by means of the various adjusting screws as described.

COMMUNUTED FRACTURES OF THE DISTAL END OF THE TIBIA

It is obviously impossible in comminuted fractures of the distal end of the tibia to apply either a regular tibial splint or one with a right angled unit attached as previously described. It is necessary to transfix the fractured leg from the proximal fragment to the os calcis and this is accomplished by applying a right angled pin bar unit to the os calcis in such a way that one pin is inserted transversely through either the lateral or medial surface from cortex to cortex and the second pin is inserted in the posterior aspect of the os calcis just medial or lateral to the Achilles tendon passing longitudinally into the body of the os calcis for a distance of about 1 $\frac{1}{2}$ or 2 inches (Fig. 143).

Before attempting any reduction maneuvers in these cases it is essential to obtain proper extension by slowly activating the turnbuckle. When the check x-ray films show that the astragalus has been properly distracted from the main proximal tibial fragment one can usually replace the distal fragments by hand. The function of the splint in these cases is to

1. Line up the main proximal fragment with the astragalus and foot.

2. Distract the main proximal fragment from the astragalus so as to make sufficient space for reposition of the displaced comminuted distal fragments. The ligamentous attachments still adherent to the fragments will very often spontaneously reduce the major displacements with proper controlled distraction which is afforded by this splint.

3. Constantly maintain the reduction of the fragments as well as the integrity of the ankle joint space during the period of healing.

The anesthesia of choice in comminuted fractures of the distal end of the tibia associated with various degrees of dislocation of the ankle joint is spinal anesthesia. With no other type of anesthesia can one safely hope to obtain the necessary relaxation so essential in these cases. Furthermore, open reduction should never be attempted until the patient has had the benefit of conservative treatment with this splint applied under spinal anesthesia. Even then if operation is decided upon the splint offers an ideal reduction frame during the

operation as well as in ideal splinting agent after the operation

MULTIPLE SHAFT FRACTURES WITH SHORT PROXIMAL FRAGMENT AND COMMINUTED DISTAL FRAGMENT

Multiple shaft fractures with a short proximal fragment and a comminuted distal fragment are usually severely compounded and associated with extensive soft tissue damage. Transfixation of the fragments must extend from the short proximal fragment to the os calcis. In this case a *right angled pin bar* is used for the short proximal fragment and for the os calcis. When the main fragments have been properly distracted by means of the external adjusting bar assembly the central fragments may in most cases be lined up by hand. A plaster splint or cast extending to the upper thigh is usually a necessary adjunct to the treatment in these extreme cases. The splint however is not incorporated in the cast.

INCIDENCE OF FRACTURES OF THE LOWER LEG

Fractures of the tibia and fibula are more common in the Navy and Marine Corps than any of the long bones of the extremities (Tabulation). compound fractures are more fre-

TABULATION

NUMBER OF FRACTURES OF LONG BONES OF EXTREMITIES IN THE UNITED STATES NAVY 1940

Bone	Simple	Compound	Total
Fibula	184	2	186
Tibia	89	19	108
Tibia and fibula	84	21	105
Radius	182	1	183
Ulna	24	4	28
Radius and ulna	28	5	33
Humerus	44	6	50
Femur	4	7	49

quently observed in this region and the incidence of being invalided from the service is higher.

Nonunion and Delayed Union as Factors in Poor Results

Nonunion and delayed union are more common in the transverse fractures of the lower third of the tibia than in any

type of fracture. Failure of bony unions according to the statistics of Bruns occurs in 0.5 per cent of all cases. Scudder on the other hand finds an incidence of nonunion of 2 to 3 per cent and Hey Groves of 4 to 5 per cent. Henderson at the Mayo Clinic found that of 211 cases of pseudo arthrosis in which operation was done 66 per cent were due to fixation by plates and screws. Scudder found that 70 per cent of thirty two cases of pseudo arthrosis resulted from the same cause.

In the transverse fractures of the lower third of the tibia callus forms slowly because the medullary cavity presents a small opening because the transversely torn periosteum is not separated from the bone because of the poor blood supply and frequent injury to nutrient vessels in this region and because the tibia has no muscle covering on its anterior or medial aspect. It requires ten to twenty weeks for union to become firm. Callus forms on the posterior and lateral aspects of the fracture long before it is formed on the anterior and medial sides. Inflammation in the lower leg is always slow to respond to treatment due to poor blood supply.

Poor treatment more frequently causes delayed union and nonunion than the injury itself. The following should be considered as contributing causes of delayed union and non union.

- 1 Interposition of soft parts
- 2 Faulty position of the fragments
- 3 Frequent interruption of fixation
- 4 Too brief fixation
- 5 Distraction of fragments by too strong traction
- 6 Multiple fractures of the shaft
- 7 Fracture of tibia with the fibula intact
- 8 Constant moving of the fragments upon one another
- 9 Infected fractures without adequate drainage
- 10 Extensive removal of fragment in comminuted open fracture
- 11 Internal fixation by plates and screws
- 12 Lack of fixation as in congenital fractures
- 13 Massage and passive movements of fractures
- 14 General disease—gumma carcinoma sarcoma osteomyelitis tuberculosis osteomalacia rickets etc

CAUSES OF FRACTURES IN THE NAVY

Fractures in the Navy may be caused by combat training athletics and injuries sustained while on liberty

1 *Combat*

- (a) Bullets from machine gun rifle or revolver
- (b) Fragments and shrapnel from shells (artillery and trench mortars) torpedoes (aerial and marine) bombs and grenades mines (marine and terrestrial) and trench clubs (knobleries)
- (c) Falls from explosions and direct injury by falling debris

2 *Training (Naval and Military Hazards)*

Nautical aeronautical submarines and machinery hazards

3 *Athletics and Recreative Sports*4 *Leave and Liberty*

- (a) Vehicles
- (b) Automobiles
- (c) Motorcycles etc

Fractures sustained while men are on leave and liberty and those that occur as a result of injuries in athletics and recreative sports are in no way different from those that incurred in civilian life. Fractures sustained in combat are usually more extensive compound and frequently comminuted.

COMPOUND FRACTURES OF THE TIBIA AND FIBULA

There is more widespread tissue necrosis in war wounds and more extensive comminution of fractures than in civilian life. All wounds should be considered infected and the wound tract is usually lined by devitalized and necrotic tissue. The breach in skin is frequently less marked than in deeper structures where disruption may be considerable. Reactionary edema is often present as a result of injury to soft tissues and outpouring of lymph into spaces. This may be delayed for one or two days and if it takes place under the fascia it may jeopardize circulation.

TREATMENT OF COMPOUND FRACTURES OF THE TIBIA AND FIBULA

- 1 If shock is present, immediate administration of plasma is imperative

2 If gas bacillus infection is suspected x ray treatment should be instituted immediately also administration of polyvalent serum

3 Booster dose of tetanus toxoid should be given in cases of previous immunization or prophylactic dose of antitetanic serum in cases in which no immunization was undertaken

4 Application of the splint prior to wound excision is important Immediate immobilization of the fragments will prevent further tissue damage relieve pain and remove shock Once the fragments are fixed and wound excision is completed reduction may be performed immediately or postponed to a later date depending upon the condition of the patient and the prevailing circumstances

Compound Fractures Received within Six to Eight Hours

The treatment of compound fractures received within six to eight hours after the injury must be instituted before inflammation is well established

1 *Excision of the Wound*—The skin around the wound is excised and the deeper parts are exposed by longitudinal incisions Thorough excision of wound tract including all damaged tissue and foreign bodies is necessary Avoid removing bone fragments attached to the periosteum and avoid injury to nerves and vessels Leave no tabs of muscle fascia or fat Healthy muscle bleeds and contracts and brick red colored muscle may indicate early anaerobic infection Failure may be the result of poor judgment in selection of cases for treatment inadequate exposure of wounds undue sacrifice of skin and tissues transverse section of muscle and skin incomplete hemostasis or additional trauma by forcible retraction and poor technique

Local Implantation of Sulfonamides—A sulfonamide in the amount of 405 gm is applied locally and a sulfonamide blood level of 6 to 8 mg per 100 cc is maintained by oral or parenteral administration until danger of infection has subsided As chlorine substance has been found to increase the effectiveness of the sulfonamide fifty times the wound should be irrigated with chlorine Tension incisions are made on each side and the skin is closed over wounds It is best to

avoid buried sutures and drainage tubes. This practice invites infection.

3 *Perfect Immobilization to Give Complete Rest and Tissue Support*—(a) The *Stader reduction and fixation splint* is ideal in handling large numbers of fractures. It gives efficient immobilization and therefore provides tissue support and prevents edema. It permits close observation of the limb without interference with immobilization. This is especially desirable when treating a large number of fractures when the element of time is important and when debridement is impractical. Under such conditions the application of the Stader splint plus the local implantation of a sulfonamide and the maintenance of a blood level of 6 to 8 mg per 100 cc by the oral or parenteral administration of a sulfonamide affords the most practical method.

(b) The *Orr closed plaster method* may be employed if the splint is not available. An accurately molded plaster cast is left untouched as long as possible, usually about six weeks, but adequate blood supply to the limb must not be in doubt. Fenestrations and splitting of the cast will negate the fundamental advantages of this treatment, namely the complete rest to injured tissues, the control of edema and the avoidance of frequent change of dressings.

Compound Fractures Received after Twelve to Twenty-four Hours

The treatment of compound fractures received late demands considerable experience and judgment as to when or when not to operate. The general condition of the patient should be the primary consideration. A rising pulse rate, pain in and about the wounds, marked tenderness, a sensation of tension, increasing edema, thin, foul, sanguineous discharge (anaerobe) and a spreading mottled bronzing discoloration of the skin in a patient who is pale and apathetic and does not respond to treatment are indications of deep and spreading infection.

The fundamental considerations in late cases of compound fracture are the treatment of shock, proper immobilization and treatment of infection.

1 Plasma is given to combat shock.

2 Prophylactic treatment for tetanus and gas infection is administered and morphine is given for pain

3 The Stader splint is applied for the purpose of establishing perfect immobilization and complete rest of the part without unnecessary manipulation. No squeezing, scraping or rubbing which will detach the thrombus and release toxins and organisms is indulged in.

4 With fixation well established free drainage should be instituted. Foreign bodies should be removed and obviously devitalized tissue, particularly muscle, must be excised without damage to the lining wall of wound. This is not wound excision or debridement which should never be attempted after twelve to twenty hours. Measures to control hemorrhage are instituted. Sulfonamide is implanted and the wound is packed lightly with vaseline strips, avoiding the use of drainage tubes. In cases of suspected gas gangrene, x-ray therapy alone may be sufficient and surgery may not be indicated. Careful early treatment will avoid a high rate of amputation. Polyvalent sera should be used in all suspected cases. In addition to the local implantation of sulfonamide, its oral or parenteral administration is of importance to maintain a blood level of 6 to 8 mg. per 100 cc. until danger of infection has completely subsided.

ERRORS IN THE TREATMENT BY EXTERNAL FIXATION

- 1 Failure to pull skin toward fracture when inserting pin in order to prevent tension when traction is applied. If tension is evident after necessary traction has been applied, a longitudinal incision in the skin should be made near the pin. Excessive tension on the skin interferes with reduction maneuvers and causes ischemic necrosis of the skin.
- 2 Failure to transfix both cortices. Pins should be introduced through the pin bar and the pin bar should be held parallel to the fragment.
- 3 Preliminary drilling for pins should not be undertaken. Drilling should be made by pins which when once inserted should remain in place.
- 4 Electrically driven drills should not be used since they

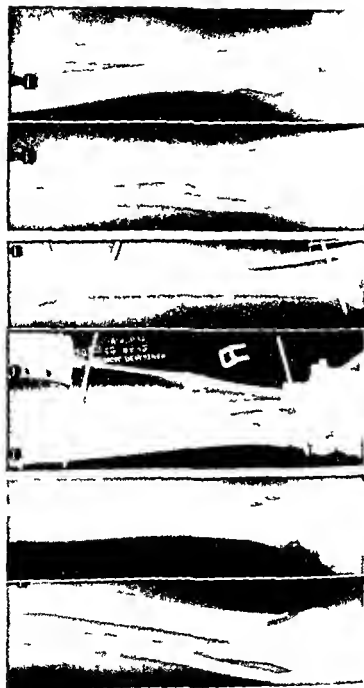
cause marked thermal reaction. A flexible shaft hand drill operated by an assistant is best. The operator may then concentrate on the introduction of the pin in its proper position.

- 5 Insertion of pins through important anatomical structures
- 6 Failure to secure alignment of extremity before insertion of half pin unit
- 7 Failure to obtain all possible reduction by manipulation first. After manipulative reduction the rest of the reduction to anatomical position may be undertaken by the apparatus
- 8 Too strong impaction causes tissue necrosis and may result in bowing—anterior posterior lateral or medial
- 9 Failure to approximate properly. Distraction results in delayed union and nonunion
- 10 Forceful and rapid traction will result in injury to soft tissues and may interfere with the circulation and impair the blood supply especially in the presence of excessive swelling
- 11 If satisfactory reduction and alignment are not obtained in a reasonably short time the failure is usually the result of soft tissue interposition between fragments. Open reduction should be undertaken to free fragments from soft tissue and external fixation reapplied. This should be completed prior to the tenth day from time of injury. Further delay beyond this period of time may result in delayed union
- 12 Failure to take x-ray pictures before and after reduction and during the period of follow up
- 13 Failure to administer anesthesia

REPORT OF CASES

Oblique Fractures of Tibia

CASE 1 (Fig. 144)—A H. aged twenty seven years on September 8, 1947 suffered simple fracture of the distal third of the right tibia and fibula. A Stader splint was applied on September 19. The distal unit was placed so that one pin was in the tibia and one in the os calcis to control tibiofibular separation. The patient was out of bed on crutches on the following day. The Stader



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 B
 C
 D
 E

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splint was removed November 1 and a walking cast was applied the latter being removed December 21 1947. Firm union resulted. Immobilization by the Stader splint had been maintained for

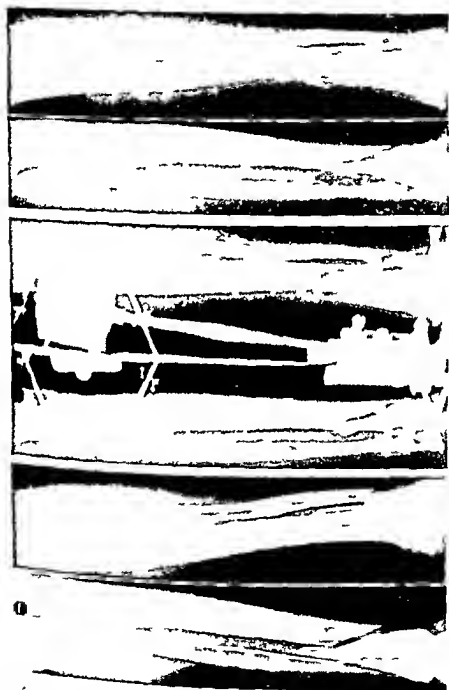
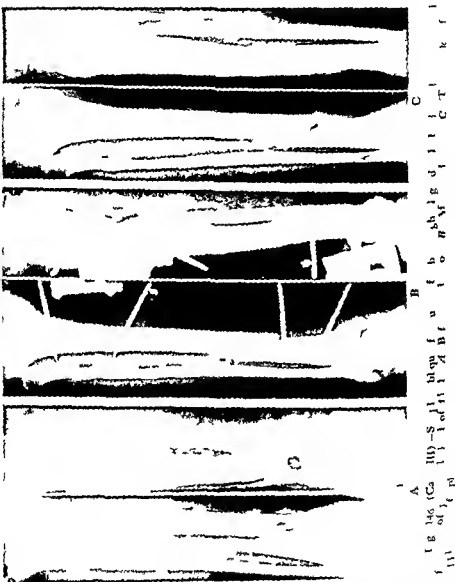


Fig. 145 (Case 11) - Simple oblique fracture of tibia right leg, distal third with tibular fracture in proximal third. A Before reduction B After reduction C Eight weeks after injury

forty two days and by the walking cast for fifty one days making a total of ninety three days.
Final result full function

CASE II (Fig 145) — O K aged forty seven years on September 29 1942 met with a simple fracture of the distal third of the right tibia and fibular fractures of the proximal and distal thirds



A Stader splint was applied October 1 using the right angled unit to short distal fragment Partial weight bearing on crutches was permitted on the following day The Stader splint was re



Fig 147 (Case IV) --Simple oblique fracture right leg distal third in tibia previously fractured and plated with fracture of middle third of fibula A Before reduction B After reduction C Five weeks after application of splint

moved December 20, 1942. Firm union resulted. Total immobilization with the Stader splint had been maintained for eighty days.

Final result: full function.

CASE III (Fig. 146) — L. S. aged fifty-three years on September 9, 1942, suffered an injury consisting of a simple oblique fracture of the distal third of the right tibia and a simple comminuted fracture of the proximal third of the right fibula. He had two pin transfixation and cast with unsatisfactory reduction elsewhere. Cast and pins were removed October 6 and a Stader splint was applied October 26, thirty-four days after the injury. The patient was out of bed by November 6 with partial weight bearing on crutches. Full weight bearing began December 1 and the Stader splint was removed December 22, 1942. Firm union resulted. Total immobilization with the Stader splint occupied seventy-seven days. Because the patient had developed bronchopneumonia one week after injury and suffered the additional serious handicap of blindness, weight bearing in this case was delayed.

Final result: full function.

CASE IV (Fig. 147) — E. B. aged fifty-three years had had a previous fracture of the tibia on July 23, 1940, which was plated elsewhere. He returned to work eleven months later. On December 12, 1942, he suffered a simple oblique fracture of the distal third of the same tibia and a fracture of the middle third of the fibula. A Stader splint was applied December 18 and partial weight bearing with crutches began the next day. Full weight bearing was allowed February 1, 1943. X-ray on January 31, 1943, shows very good union after a period of fifty days of immobilization with the Stader splint. The patient is still under treatment.

Transverse Fractures of Tibia

CASE V — E. P. aged forty-nine years on February 17, 1942, met with a compound fracture of the tibia and fibula, distal third right leg. Associated injuries consisted of simple fractures of the second, third, fourth and fifth metatarsals of the left foot. A Stader splint was applied to the right leg on February 22 and removed May 19, but union was not firm. A walking cast was thereupon applied and removed July 1, 1942. Firm union resulted. Immobilization with the Stader splint had been maintained for

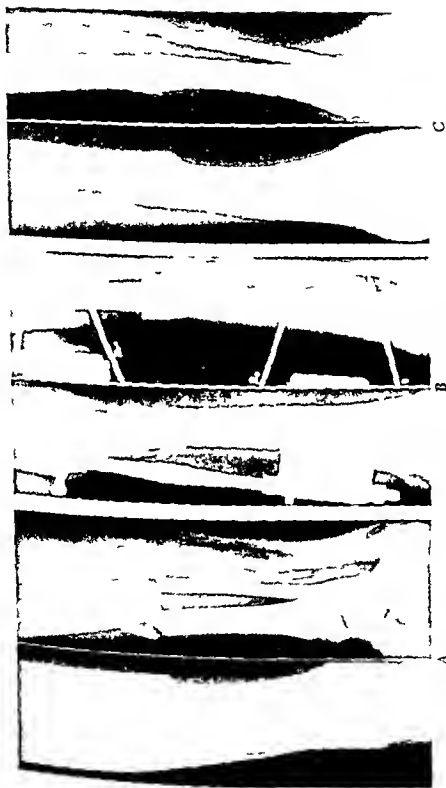


Fig. 148 (Cont.)—Simple transverse fractures of tibia and fibula right leg in middle third. A Before reduction B After reduction C Nine months after injury D After reduction B

moved December 20, 1942. Firm union resulted. Total immobilization with the Stader splint had been maintained for eighty days.

Final result: full function.

CASE III (Fig. 146) —E. S., aged fifty-three years, on September 9, 1942, suffered an injury consisting of a simple oblique fracture of the distal third of the right tibia and a simple comminuted fracture of the proximal third of the right fibula. He had two pin transfixation and cast with unsatisfactory reduction elsewhere. Cast and pins were removed October 6 and a Stader splint was applied October 26, thirty-four days after the injury. The patient was out of bed by November 6 with partial weight bearing on crutches. Full weight bearing began December 1 and the Stader splint was removed December 22, 1942. Firm union resulted. Total immobilization with the Stader splint occupied seventy-seven days. Because the patient had developed bronchopneumonia one week after injury and suffered the additional serious handicap of blindness, weight bearing in this case was delayed.

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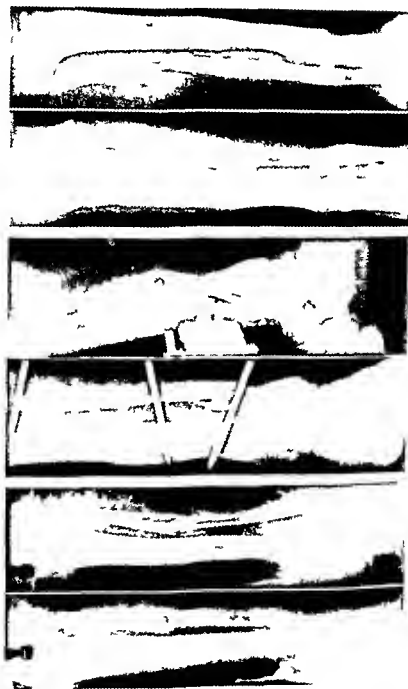
were completely healed. No infection was present. The patient is still under treatment and progress is satisfactory.



Fig 151 (Case XI) —Multiple compound fractures of tibia and fibula with tibiotalar dislocation and fracture of internal malleolus. A and B Before reduction. C Composite view of multiple fractures. D and E After reduction.

Fractures with Associated Osteomyelitis

CASE XII (Fig 152) —E S, aged fifty three years, had previously suffered a compound fracture of the lower right leg on



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 y l A B f du n
 d nquy



Fig 153 (Case VIII) —Simple fracture of tibia and fibula right leg middle third Bone plating, elsewhere has been followed by osteomyelitis *A* Before removal of plates and saucerization of tibia *B* After operation *C* Ten months after operation

January 19, 1941 followed by osteomyelitis. On March 10, 1942 he refractured the right tibia and fibula. Previous treatment elsewhere consisted of two pin transfixation and cast which resulted in unsatisfactory reduction. The cast and pins were removed and a Stader splint was applied on April 14, 1942. The patient had chronic osteomyelitis with a draining sinus. He was out of bed on crutches with partial weight bearing by April 16. The Stader splint was removed July 1. Firm union had resulted but a walking cast was applied which was removed on July 22, 1942. Immobilization in the Stader splint had been maintained for seventy-eight days and in the walking cast for twenty-two days making a total of 100 days of immobilization.

Final result: firm unions, sinus completely healed.

Case VIII (Fig. 153).—C. T. aged forty-two years was injured February 7, 1942, suffering simple fractures of the right tibia and fibula in the middle thirds. Previous treatment elsewhere consisted of bone plating which was followed by osteomyelitis. A Stader splint was applied March 9 and the bone plates were removed and the area saucerized. The patient was permitted on crutches with partial weight bearing two days later. The Stader splint was removed on July 24, 1942, after 137 days of immobilization with the splint.

Final result: complete function.

Other patients still under treatment with the Stader splint show every evidence of satisfactory union.

CLINICAL ANALYSIS

1. All oblique fractures unite much more rapidly than the transverse type. The average period of immobilization of oblique fractures was eighty-three days and of transverse fractures 157 days.

2. Four severely compounded fractures of the tibia responded to treatment with the Stader splint in a manner similar to that of the simple type.

3. The splint may be applied several days after fractures occur and satisfactory results may be obtained without open reduction. In one case the splint was applied fourteen days after the fracture and in another thirty-four days after the

fracture The men were restored to duty without any disability (See Figs 146 152)

4 By means of the Stader splint all fractures were reduced and maintained in the desired position without any difficulty

5 No infection occurred about any of the pin sites The average period of healing of the sites was six days In only two cases was there a delay in healing in one case fourteen days and in the other twenty days This delay in healing was about one pin site only in each case

6 Bone reaction to pins was that of a very slight periosteal thickening about a few pin sites No sclerosis about pin sites or ring sequestra were seen

7 All patients had complete motion in knees and ankles in an average of five days after application of the splint No physical therapy was required in any case

8 All patients other than those with associated injuries became ambulatory with crutches and partial weight bearing the day following the application of the splint

9 By means of external fixation a patient is restored to duty much earlier than those successfully treated by internal fixation (See Fig 147)

10 Cases of acute or chronic osteomyelitis following infection after internal fixation are being treated successfully by Stader splint after removal of the plates and screws and thorough saucerization (See Fig 153)

11 Transfixation pins incorporated in plaster are not always a successful method either for reducing the fracture or retaining it in proper position Two patients admitted after the fracture fragments were not properly reduced by this method elsewhere had the cast and transfixation pins removed and a Stader splint applied Reduction was easily obtained and maintained (See Figs 146 152)

12 The Stader splint is ideal for treatment of comminuted fracture of the tibia where accuracy of reduction is essential to avoid impaction or distraction (See Fig 151)

13 Multiple fractures of the shaft whether simple or compound are amenable to this method of treatment which is better than any method that we have tried (See Fig 151)

14 In old fractures with considerable loss of substance of

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The
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NORTH AMERICA

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THE SURGICAL CLINICS of NORTH AMERICA

Lahey Clinic Number

MANAGEMENT OF BILIARY TRACT DISEASE

FRANK H. LAHEY

DEALING as this volume does in part with biliary tract disease, presentation of this subject first from a general point of view seems worth while. In discussing biliary tract disease I would like to consider it from the same aspects as are numerous other diseases such as hyperthyroidism, tuberculosis, diabetes, prostatic hypertrophy and malignancy. There seems little likelihood that the present surgical management of biliary tract disease will be greatly improved or supplanted by other measures. After having been intimately concerned for a number of years with the treatment of cholelithiasis, cholecystitis and its associated lesions, it seems to me that improvement in this field from now on must come largely through discovery of the causes, particularly of cholelithiasis, and lacking that, earlier diagnosis of biliary tract disease and earlier surgery, since that is the only method of treatment now available.

The Common Association of Biliary Tract Infection and Other Complications with Cholelithiasis

If one recalls the undesirable complications of biliary tract disease, such as acute cholecystitis, pancreatitis, common duct stone, cholangitis and hepatitis linked with diminished liver function, one is convinced that delay in the treatment of this disease as in hyperthyroidism, appendicitis, malignancy and many other diseases is the avoidable factor which results in many of these unwished for serious complications.

Acute cholecystitis rarely occurs until gallstones have been present for some time until a stone becomes wedged in the cyst

tic duct and until the infected gallbladder is shut off to form a culture tube for the growth of organisms and the infiltration of the gallbladder wall.

The same thing is largely true of *pancreatitis*. The direct association of cholelithiasis, cholecystitis, infections of the common duct and pancreatitis is not definitely established and true pancreatitis apparently does occur at times unassociated with demonstrable lesions in the biliary tract. However, with the number of cases in which gallstones and infection in the biliary tract are present and the number of cases benefited by drainage of the common duct, one cannot fail to be impressed with the likelihood of association between the two.

In my mind *common duct stone* has always been closely associated with late and prolonged biliary tract infection, particularly infection and stones in the gallbladder. Courvoisier's law, which is so valuable and dependable, suggests strongly that common duct stone occurs only after prolonged infection within the gallbladder. Courvoisier's law is that in the presence of jaundice a contracted gallbladder found at operation suggests that the jaundice is due to obstruction of the duct from gallstone, while a dilated gallbladder suggests that the obstruction is due to malignancy. In support of the first portion of this law, long experience with stones in the common and hepatic ducts has taught me that almost always when the gallbladder is contracted down to the size of a peanut, as it often is, a stone within the common or hepatic duct is present.

I have further been impressed with the fact that there is little likelihood that stones in the common and hepatic ducts originate in the gallbladder. In my experience stones could rarely pass from the gallbladder through the cystic duct and into the common and hepatic ducts. The process is rather, in my opinion, one of infection originating particularly in the gallbladder and constantly bathing the common and hepatic ducts through the cystic duct, with the resultant production of stones within the common and hepatic ducts.

Cholangitis exclusive of the occasional infected common duct in the absence of stones is largely related to inadequate drainage of the biliary tract due to common duct stone, which in turn is largely related to long standing infection and stones particularly within the gallbladder.

Hepatitis and diminished liver function in biliary tract disease with the attendant danger of late biliary cirrhosis for the most part are related to long standing infection within the common and hepatic ducts and the biliary tree. This infection is secondary to stones within the common and hepatic ducts caused by back pressure stasis and infection and is also occasionally due to strictures of the duct secondary to operation or fibrosis of the sphincter of Oddi.

Earlier Diagnosis of Gallstones a Prerequisite to Better End Results in the Treatment of Biliary Tract Disease

Obviously many complications which now result in morbidity and mortality in biliary tract disease could be avoided if the possibility of gallstones were investigated on the basis of fewer symptoms at an earlier stage in the disease. The more frequent employment of cholecystography for indefinite upper abdominal pain without haphazard administration of indigestion remedies would result in many earlier diagnoses and consequently better handling. To wait for biliary colic is to wait for late stages of biliary tract disease and the dangers of complications. If we could convince patients of the wisdom of having their diseased gallbladders and gallstones removed at a stage when few symptoms are present and at a stage when they do not want it done rather than at a stage when the symptoms are advanced and they are begging to have it done fewer patients would die and many would avoid most of the undesirable complications.

Early Surgery in All Patients with Cholelithiasis

It was an unfortunate day when the term "silent gallstone" originated. There may be silent gallstones however exclusive of the true cholesterol stone they are so rare that we could well dispense with the term. It is my conviction and that of most of us here at the Clinic that when a patient has gallstones (without surgical contraindications) he is so likely to have undesirable symptoms and complications later that regardless of whether or not the immediate symptoms are urgent he should have surgery. The mortality rate in patients having cholecystectomy including those with advanced symptoms is now so low (not over 2 per cent) that we believe this to be a sound position.

The interpretation of cholecystography and the rigid appli

cation of this advice concerning operation on all patients with gallstones who are good risks suggest the possibility of unsoundness unless there are certain qualifications. As I have repeatedly written we would not advise cholecystectomy for a patient with vague digestive symptoms and simple nonfilling of the gallbladder without the visualization of stones. On the other hand with a history of repeated typical gallstone colic even though stones cannot be demonstrated and the gallbladder empties and fills if we can rule out all other lesions we unhesitatingly advise removal of the gallbladder. In such instances we have several times found BB shot like stones within the gallbladder and complete relief of symptoms followed cholecystectomy. Patients with doubtful symptoms and only nonfilling of the gallbladder should be reexamined every two or three months and the dye repeated until consistent filling or nonfilling of the gallbladder is established.

Perhaps early surgery in all patients with cholelithiasis is an impractical idealism; however the foregoing suggestions could advantageously be employed by many family physicians who first see these patients. More accurate diagnosis of many surgical lesions of the abdomen could thereby be attained particularly those about the gallbladder region, duodenal and gastric ulcer and gastric malignancy.

Early Surgical Investigation in Cases of Possible Malignancy of the Stomach and the Head of the Pancreas

In an article on earlier diagnosis of carcinoma of the stomach I suggested that any patient with indigestion lasting over a week should have thorough investigation of the possibility of these lesions. By this means many early gastric carcinomas would be found and the nonrecurrence rates would be higher. Many more ulcers would be diagnosed in their early stages while they were still tractable to medical management and many patients would have gallstones removed before undesirable complications arose.

In addition the head of the pancreas with its occasional early carcinoma of the pancreas and of the papilla can now be resected successfully. In those patients with vague indigestion and in those with painless jaundice we separate as far as possible those patients with carcinoma of the head of the pancreas the

common duct or the papilla of Vater from those whose symptoms are due to common duct stone and so called catarrhal jaundice or hepatitis. The patients with carcinoma of the head of the pancreas and the papilla not unlike those with gallstones should be given an earlier diagnosis if one wishes to give them a chance with this relatively new extension of surgery. In many cases we should be able to suspect the diagnosis before applying the second portion of Courvoisier's law that is in the presence of jaundice a dilated gallbladder is indicative that the obstruction is due to malignancy. When the delay in diagnosis is such as to permit dilatation of the gallbladder malignancy in the head of the pancreas in the papilla of Vater or in the common duct has usually been present for some time, although we should not deny these patients exploration. If progress in the diagnosis and surgical treatment of early carcinoma of the head of the pancreas or the ampulla of Vater is to be made we must be prepared after thorough investigation of patients with painless jaundice to explore the right upper quadrant even to the stage of opening the duodenum and investigating the papilla.

Improved Liver Function Following Relief of Biliary Tract Obstruction and Infection

If the liver did not possess such great capacity for regeneration and recovery of function the situation in biliary tract disease would be a depressing one. We have several times seen patients with common duct stone cholangitis and Charcot's fever associated with liver function of zero following relief of the obstruction and recovery from the infection regain 100 per cent return of liver function. We cannot assume because of this, however that long standing common duct stone with back pressure on the biliary tree and chronic cholangitis or repeated attacks of acute cholangitis do not involve the dangerous possibility of a biliary type of cirrhosis.

We must admit that the attitude that delay in biliary tract disease is harmless is almost traditional. To many of us who have dealt extensively with this state however it is obvious that better end results are possible if those physicians who first see patients with biliary tract disease will make earlier diagnoses and urge earlier operative procedures.

BILIARY TRACT SURGERY A STATISTICAL REVIEW

RICHARD B CATTELL

This volume presents a symposium dealing with certain aspects of biliary tract disease based on experience in the Lahey Clinic in the management of these cases. This subject is not presented in its entirety but rather the discussion is limited to our methods in the management of some of the biliary tract diseases particularly those in which treatment has changed in recent years.

During the last decade an increasing interest in surgery of the common duct has been evident particularly in the management of common duct stones and benign strictures. A definite change in the management of acute cholecystitis has taken place. The successful management of malignancy in the pancreatoduodenal area has been achieved recently and improvement has taken place in the management of obstructive jaundice regardless of its cause.

A brief statistical summary of biliary tract surgery which provides a comprehensive view of this problem is presented. The papers which follow deal with special aspects or conditions from this group of patients.

From 1910 to 1947 inclusive 3,373 patients with gallbladder disease were operated upon at the Lahey Clinic (Table 1). In

TABLE 1
GALLBLADDER OPERATIONS

Year	Gallbladder Disease	Common Duct Explorations	Common Duct Stones	Operative Mortality
1910-1947	3,373	1,297 (38.6%)	479 (14.2%)	105 (3.01%)
1930-1933	493	198 (40.2%)	98 (20.0%)	11 (2.2%)
1934-1937	634	284 (44.8%)	103 (16.2%)	20 (3.1%)
1938-1941	909	444 (48.8%)	128 (14.1%)	21 (2.3%)
1942-1947	287	130 (45.3%)	28 (9.8%)	3 (1.1%)

this group 1 792 patients had their common ducts opened and explored and 479 had common duct stones. In the entire group there were 105 deaths a mortality of 3.01 per cent. It is interesting to observe that 34 or approximately one third of the operative deaths occurred in patients with common duct stone.

In the last thirteen years 180 patients with malignancy of the liver pancreas gallbladder bile ducts and ampulla have been operated upon. Fifty three deaths occurred in this group although with 6 exceptions the operation was of a palliative nature.

In order to evaluate more recent experience we divided the twelve year period between 1930 and 1941 inclusive into three four year periods and finally listed the cases for 1942 (Table 1). Two observations were made relative to the change in the statistics for 1942. The number of common duct explorations remained about the same yet there was a marked drop in the incidence of common duct stone. It seems likely that this is due to the fact that gallbladder disease is being discovered earlier because of careful and complete gastro enterologic studies on an increasingly large group of patients with digestive symptoms. The second observation was the marked reduction in operative mortality. For a number of years it remained between 2 and 3 per cent and it now is approximately 1 per cent. As mentioned previously the mortality of gallstone surgery is closely related to the incidence of common duct stone and delayed treatment of gallstones. The fact that only 3 patients died following operations on the biliary tract exclusive of malignancy does not mean that there were few complicated cases since this group includes the repair of 6 common duct strictures 4 patients with carcinoma elsewhere in the gastro intestinal tract 4 with acute pancreatitis 5 with duodenal ulcer 3 with cirrhosis of the liver 2 with perihepatic abscesses and a large number of secondary operations on the gallbladder. This reduction of mortality has also been aided by better preoperative and postoperative care.

The incidence of malignancy if one includes the liver and pancreas is surprisingly high. During 1942 there were 29 carcinomas representing about 1 patient with malignancy to 10 with gallbladder disease. The incidence of malignancy from 1930 to 1941 inclusive is shown in Table 2. In this period 151 patients had malignancy a percentage of 6.9.

TABLE 2
CARCINOMA OF BILIARY TRACT

Incidence 1930-1941 Includes	Number	Percent
All non-malignant gallbladder operations	2,036	93.1
Carcinoma of biliary tract	151	6.9
Total	2,187	100.0

Table 3 shows the location of the malignancy for the longer period and also for 1942. In 1942 there were 29 malignancies

TABLE 3
CARCINOMA OF BILIARY TRACT

Location	1930-1941	1942	1930-1942
Pancreas	90	17	107
Ampulla	8	4	12
Bile ducts	13	1	14
Liver	15		15
Gallbladder	25	4	29
Total	151	29	180
Operative mortality	40 (26.5%)	5 (17.2%)	(25%)

with 5 deaths. Included in the 29 cases were 4 radical pancreatoduodenectomies without operative mortality.

ACUTE CHOLECYSTITIS

SAMUEL F. MARSHALL

THE treatment of acute cholecystitis presents a problem about which there is no agreement as to the optimum time of surgical intervention. Recently the medical literature has been filled with reports on this subject.

Attempts have been made to classify patients with acute cholecystitis from a clinical standpoint into various groups and to give fixed rules concerning when operation should be performed and what method of surgical management should be employed. The results in groups of cases are cited to indicate the effectiveness of such efforts to classify cholecystitis from the standpoint of degree of acute inflammation, age of patients, rapidity of progression of symptoms and presence of complications.

Although this effort to classify acute cholecystitis into groups may be commendable, it has caused great confusion as to proper treatment. It has also detracted from the most important consideration which is whether the patient should be operated upon as early as possible and whether acute cholecystitis should be considered as one of the differential problems of acute disease within the abdomen.

Our experience has been that while in most cases the diagnosis of acute cholecystitis is relatively easy, it may be difficult to classify many of these patients into definite groups and to apply rigid rules of treatment. A common experience is that symptoms, abdominal signs and laboratory findings do not always give reliable indications of the severity of the inflammatory process in the gallbladder (Case II) and that watchful waiting may lead to serious complications. These factors increase the operative mortality, particularly in the older age group.

It is our custom to regard every case of acute cholecystitis as an emergency and to operate as early as possible (Case I). This does not mean that sufficient time cannot be spent in restoring fluid balance and correcting alteration in blood chemistry. Intravenous glucose will do much to restore the storage of glycogen in the liver and prevent liver damage resulting from serious

inflammatory processes and from the shock of surgical intervention

Much of the danger of acute cholecystitis can be avoided if chronic cholecystitis with stone is recognized by the physician and evaluated properly. Too often patients are advised against operation for gallstones incidentally discovered by roentgenologic examination during other studies. *There is no such thing as harmless or silent gallstones.* Gastrointestinal symptoms referable to gallstones always can be elicited if the patient is questioned. The danger of serious complications among which is acute cholecystitis is always existent as long as stones are present. Gallstones should be removed as early as possible after their discovery at a time when surgery can be elective and when surgical intervention can be accomplished with minimal risk.

It is recognized that the operative mortality of acute cholecystitis is definitely greater than that of elective gallbladder removal. It is also conceded that the acute cholecystitis commonly referred to represents an acute inflammatory process superimposed on an old chronic cholecystitis associated with gallstones, a process which in many instances could be diagnosed and treated before the occurrence of acute inflammation.

Many cases of acute cholecystitis represent the acute obstructive type seen so commonly with obstruction of the cystic duct with an impacted stone. In the presence of active gallbladder infection this leads to serious complications such as gangrene, perforation with abscess or peritonitis and acute hepatitis with jaundice. It is evident that early operation will prevent the development of such complications and will greatly reduce the technical difficulties and operative hazard. With delay edema and induration will involve the gastrohepatic tissue about the common duct and hepatic vessels which tends to make dissection and visualization of the cystic artery and cystic duct more difficult and more hazardous. With obstruction of the cystic duct it is surprising how rapidly inflammation will progress and how early an enlarged tender gallbladder can be palpated through the abdominal wall. This type of acute cholecystitis will rapidly become gangrenous and perforate early. The palpable mass represented by a hydrops of the gallbladder is a chronic process and does not present the symptoms and signs

of an acute inflammatory process and consequently does not require immediate surgical intervention

The treatment of acute disease of the gallbladder would be simplified greatly if the patient would present himself to the physician immediately after the onset of his symptoms. Operation could then be performed at an optimum time within six to twelve hours after the onset of symptoms (Case I) before the development of marked inflammation and complicating factors. This would permit establishment of a definite diagnosis, evaluation of the patient's general physical status and restoration of fluid and chemical balance.

It is evident that patients with early symptoms suggesting gall bladder disease *should be admitted to hospital at once*, whether day or night so that proper laboratory studies may be obtained immediately. However often the surgeon does not see the patient until two, three or four days after the onset of symptoms. If the patient gives evidence of a subsiding inflammatory process indicated by decreasing symptoms, tenderness, temperature and leucocytosis, operation can be deferred for a day or two. However operation should be undertaken as soon as possible if the patient has been ill at home for several days, if no improvement has followed conservative measures or if a serious inflammatory process is present in the right upper quadrant accompanied by high temperature, a rising leukocyte count, localizing signs of marked tenderness and even muscle rigidity (Case III). These signs which often indicate impending or actual perforation or gangrene may require cholecystectomy or only drainage of the abscess. Drainage is undertaken particularly in patients who are elderly or in poor physical condition. Operative fatalities are most frequent in the latter group.

It should be emphasized that patients with pain in the right upper abdomen should be regarded as having an acute condition and should be admitted at once to the hospital. Typical acute cholecystitis is readily recognized but atypical cases may be confused with perforated peptic ulcer, pancreatitis or even acute appendicitis. Not infrequently the sudden onset of coronary occlusion may simulate a gallbladder attack. Early recognition of the true pathologic condition is advisable but very often surgery must be instituted immediately because accurate diagnosis is impossible and a catastrophe is imminent. Again because of

this confusion with other abdominal disease operation for acute cholecystitis may be delayed until marked inflammatory changes have taken place (Case III)

Acute disease within the abdomen presents so many difficult problems that the opinion of other consultants should be sought freely and an early decision made concerning surgery. Only thus can the surgeon avoid serious complications which add to the operating hazards.

It is our custom in the Lahey Clinic and we believe it is good judgment to remove the gallbladder in the majority of patients with acute cholecystitis. The same criteria that indicate necessity for common duct exploration in chronic cases also govern the opening of the common duct in the presence of an inflammatory gallbladder. Morbidity and mortality in acute cholecystitis have not been increased by choledochostomy over that noted in elective gallbladder operations.

Ordinarily if much inflammation or induration of the subserous tissues is present about the gallbladder and gastrohepatic area we detach the gallbladder in the liver bed from the fundus down isolating the cystic artery and cystic duct and ligating them separately. The common duct is visualized and opened as indicated. In the presence of marked inflammation this method permits isolation of the cystic artery and duct somewhat more easily than the routine method commonly used in this Clinic, that is isolation, ligation and division of the cystic artery and cystic duct before dissection of the gallbladder from its liver bed. Cholecystostomy is rarely necessary and we have employed it only in elderly or poor risk patients with gangrene perforation or abscess.

REPORT OF CASES

CASE I—A woman aged 73 years whose previous health had been excellent developed pain in the right upper quadrant of the abdomen twelve hours before admission to the hospital. The pain was severe colicky and associated with nausea and vomiting. At first there was no tenderness over the gallbladder and no palpable mass but ten hours after the initial symptoms, marked tenderness and a large palpable mass in the gallbladder area were noted. The temperature was 98.4 F and the pulse rate was 80. The leukocyte count was 18,100 and the polymorphonuclear neutrophil leukocytes 90 per cent. Intravenous glucose was given and fourteen hours after the onset of dis-

tress operation was undertaken under spinal anesthesia using a pontocaine glucose solution

The gallbladder which was distended tense edematous and markedly hyperemic was detached from the liver from the fundus down isolating the cystic artery and the cystic duct A single large stone which caused obstruction was impacted in the ampulla of the gallbladder The common duct was normal and was not opened The patient had an elevated temperature (never over 100 F) for only four days after operation She made an uneventful recovery and was discharged sixteen days following operation

The pathologic diagnosis was acute cholecystitis A culture of the gallbladder contents revealed *Bacillus coli*

Comment—This case illustrates acute cholecystitis which was treated as a surgical emergency The patient's preoperative course indicates the rapidity with which inflammatory changes develop especially in the presence of obstruction The uneventful convalescence confirms the value of early operation

CASE II—A woman aged 54 years was admitted to the hospital with a history of attacks of epigastric pain for nine days and marked tenderness over the right upper abdomen immediately after the onset of pain There had been no vomiting or nausea There was a history of similar right upper quadrant pain two years before but the symptoms completely subsided after a short time

The patient was obese There was moderate tenderness in the right upper quadrant of the abdomen There was no muscle spasm The temperature was 99.6 F and the pulse rate was 88 The leukocyte count was 7,400 and polymorphonuclear neutrophil leukocytes 66 per cent The serum bilirubin was 0.1 mg per cent Roentgenologic examination of the abdomen showed a large gall stone She was given intravenous glucose and vitamin C and operation was performed on the third day after admission

Upon opening the abdomen the gallbladder was distended edematous and hemorrhagic The omentum duodenum and pylorus of the stomach were closely adherent to the inflamed mass A large stone was impacted in the ampulla of the gallbladder The gall bladder was removed from the fundus down isolating the cystic artery and duct from very indurated edematous tissue in the gastrohepatic omentum The common duct was not opened The convalescence of the patient was uneventful

Pathologic examination revealed a markedly hemorrhagic and necrotic mucosa and an acutely gangrenous gallbladder with infarction

Comment—This case illustrates acute cholecystitis with admission to the hospital nine days after the onset of symptoms. The first attack apparently subsided but attacks of pain recurred at intervals. The pathologic process was much more advanced than the symptoms, signs and laboratory findings indicated. This is frequently true of acute cholecystitis when operation is not undertaken until a number of days following the initial attack. Operation would have been much easier from a technical standpoint earlier in the course of the disease and certainly would have been less hazardous.

CASE III—A man aged 42 years was admitted to the hospital with a history of severe epigastric pain and vomiting for twenty-four hours. There was a history of duodenal ulcer with typical periods of exacerbation and remission over twenty years. The present attack was similar to previous milder attacks.

The temperature on admission was 98.4 F and the pulse rate was 80. There was slight tenderness over the gallbladder and in the epigastrium but no rigidity. The leukocyte count was 13,650. The history and abdominal findings suggested an acute exacerbation of the ulcer. Localizing signs in the gallbladder area became more definite with the development of muscle spasm. The leukocytes on the second day were 12,200 and the polymorphonuclear neutrophil leukocytes 90 per cent. On the second day the symptoms suggested acute cholecystitis and immediate operation was advised.

Exploration revealed a gangrenous gallbladder with adherent adjacent viscera. The gallbladder was dissected free from the liver from the gallbladder fundus down toward the common duct. The cystic artery and cystic duct were isolated and ligated separately. Culture of the serous exudate about the gallbladder showed *Bacillus coli*. A cigaret drain was placed down to the foramen of Winslow. For four days following the operation the patient's course was stormy. The temperature rose to 104 F and then gradually subsided to normal. There was considerable purulent drainage from the wound. He was discharged twenty days postoperatively.

Pathologic examination revealed a deep red mucosa and serosa with the gallbladder walls presenting greenish yellow necrotic areas. The diagnosis was an acute gangrenous gallbladder.

Comment—This case illustrates rapidly progressing inflammation of the gallbladder with gangrene developing in the gallbladder and infection extending through the necrotic wall. Gross perforation was probably prevented by adherence of

omentum and adjacent tissues. It also increases the difficulty in arriving at a correct diagnosis in the case of an ulcer which had been treated for years. If the disease process had been recognized at once, operation could have been performed much earlier and subsequent intra-abdominal infection avoided. Although the patient recovered after a short convalescence yet he had a wound infection which resulted in a ventral hernia, and the operative risk was increased.

SUMMARY

Acute cholecystitis should be considered as an emergency demanding immediate admission to the hospital. Operation should be performed as early as possible. However sufficient time may be allowed to establish the diagnosis, to evaluate the risk from a physical standpoint and to restore fluid, chemical and protein balance. In the majority of cases cholecystectomy is preferred to cholecystostomy.

GALLBLADDER DISEASE DIAGNOSIS AND POST OPERATIVE MEDICAL TREATMENT

SARA M. JORDAN

CHOLECYSTECTOMY now the standard operation for disease of the gallbladder is so valuable and so often a life saving procedure that the finding of a diseased gallbladder to explain digestive symptoms is usually a satisfying result of a gastro intestinal survey—satisfying because a definite cure can be offered the patient. Yet not infrequently a recalcitrant attitude on the part of the patient is encountered—an attitude engendered by the experiences of relatives or friends who still had the same symptoms after the gallbladder was removed. Furthermore a careful analysis of the results of cholecystectomy will reveal a varying percentage of poor results.

Several factors are responsible for these poor results first inaccurate diagnosis of gallbladder disease and secondly inadequate postoperative care of other preoperatively unrecognized digestive abnormalities associated with disease of the gallbladder. To these most common causes of poor postoperative results must be added the failure at operation to find common duct stones or a small carcinoma of the head of the pancreas bile ducts or ampulla.

The need for cholecystectomy is well recognized today. Many of the most conservative internists have been converted to the need for cholecystectomy for the so called "silent" and the presumably single stone. The former often has proved troublesome and dangerous in later years and the latter often has been found to be multiple on cholecystectomy. The diagnosis of cholelithiasis is in itself usually an indication for cholecystectomy even though the usual symptoms are mild or absent. But with more patients being subjected to surgical treatment the need for accuracy in diagnosis and for the use of every measure to effect good end results has become increasingly important.

The purpose of this paper is to discuss the diagnosis and post operative medical treatment.

DIAGNOSIS

The accuracy of diagnosis of gallbladder disease depends upon two fundamental factors (1) the type of gallbladder disease requiring surgery and (2) the diagnostic criteria by which an accurate diagnosis is made

In the experience of the Mayo Clinic four conditions in the gallbladder require surgery. In the order of frequency of occurrence they are (1) cholecystitis with stones (2) acute sometimes gangrenous cholecystitis with cholangitis and cholelithiasis without stones (3) papillomas of the gallbladder and (4) carcinoma of the gallbladder

In the diagnosis of *cholecystitis with stones*, the history plays a very important role but even the most typical history of colic must be supported by roentgenologic evidence. Other conditions may produce severe colicky pain in the right upper quadrant of the abdomen with radiation to the back, chest and lower abdomen. From the history alone the three conditions most easily confused with gallbladder colic are (1) coronary thrombosis (2) disease of the right kidney and (3) acute spasm either of the duodenum or of an irritable colon with gas pocketing and spasm at the hepatic flexure

Occasionally pain from a penetrating duodenal ulcer of the posterior wall of the bulb or of the second part close to the ampulla may be confused with gallbladder disease and especially so if in the latter group jaundice results from obstruction of the sphincter of Oddi

The characteristic vomiting of gallbladder disease may occur in all these conditions however it occurs less frequently in the functional conditions. The vomiting is due to the acute pyloro-spasm which so often attends severe pain elsewhere in the body even though the cause of the pain may be remote from the digestive tract. If the acute indigestion with severe pain is nocturnal in onset gallbladder disease or the severe type of coronary disease is the most probable diagnosis. Except in the cases of duodenal ulcer close to the ampulla jaundice with the attacks makes the diagnosis of gallbladder disease practically certain. In cholelithiasis neither fever nor leukocytosis needs be present

An inflammatory reaction within the walls of the gallbladder may vary from *mild cholecystitis* to the *severe gangrenous type* with acute localized tenderness, fever and leukocytosis with or

without jaundice. In the latter group of cases associated pancreatitis is often present and the question of the optimum time for operation arises. With modern surgical technic the risk of perforation, continued toxemia and dehydration without surgery is often much greater than the risk of surgery even in the acute stage but the decision in the individual case is a matter of clinical judgment.

There is no characteristic history of *papillomas of the gall bladder*. They are usually discovered through visualization of the gallbladder by the Graham test and because of their dangerous potentialities cholecystectomy is usually advised.

Carcinoma of the gallbladder is likewise not characterized by definite symptoms but should be suspected if jaundice and right upper quadrant distress are progressively severe especially with the gradual onset of the usual suspicious symptoms of progressive loss of appetite and weight. Preoperative differentiation from carcinoma of the head of the pancreas or bile ducts is usually impossible.

In my opinion the preoperative diagnosis of gallbladder disease even though the history and radiologic findings are definite should be made only after a careful survey of the rest of the digestive tract. Such conditions as achlorhydria, diverticulosis, irritable colon and of course an ulcer should be determined preoperatively. All these conditions are frequently found in association with gallbladder disease and it is important to know of them preoperatively not only because certain of these conditions require special preoperative care but also because the postoperative management of such cases is such a potent factor in effecting satisfactory end results.

The *Graham Cole test* has been of incalculable value in the diagnosis of gallbladder disease. Like all such tests its interpretation has developed with experience. For practical purposes two diagnostic criteria are considered essential: (1) failure of the gallbladder to fill with the dye and (2) consistent appearance of irregular shadows either radiolucent or opaque within the gallbladder wall.

Orally administered dye can be considered a satisfactory test only if it shows a normal gallbladder or definite shadows of stones but intravenously administered dye should always be used as a check if there is nonfilling of the gallbladder. Non

visualization of the gallbladder with the dye indicates failure of absorption of the dye or failure of functioning of the gallbladder; however, it is most important to distinguish between functional failure due to organic disease in the gallbladder itself and failure due to a temporary cause, probably spasm and presumably spasm of the sphincter of Oddi, which is relieved when the cause outside the gallbladder is corrected. Such a cause may be an acute duodenal ulcer or an acutely irritable colon, and following relief of this condition the previously nonfilling gallbladder may be normally visualized. In other words, greater accuracy in the diagnosis of gallbladder disease requiring surgery can be attained if, when the orally administered Graham-Cole test is positive for disease, it is considered equivocal (1) until disproved by a negative intravenously administered test or (2) if after a period of treatment of an associated peptic ulcer or irritable colon the intravenously administered test is again positive. At the Lahey Clinic we do not usually consider faint filling and slow emptying of serious import unless associated with opaque or radiolucent shadows indicating stones. These less definite findings are due usually to functional disturbances or possibly to a mild inflammatory process in the gallbladder from which recovery on a medical regimen is possible.

POSTOPERATIVE MEDICAL TREATMENT

The work of Ivy and his colleagues on the physiology of the biliary tract has shown experimentally what has been confirmed by experience clinically—that the gallbladder with its bile reservoir and pressure regulatory mechanism is associated intimately with the function of the duodenum. Specifically, his results show among other things the effect of duodenal irritation and irritability upon the tonicity of the sphincter of Oddi and the production by the latter of dilatation of the common duct and the occurrence of pain. While the tonicity of the sphincter of Oddi is decreased after cholecystectomy, it may later become abnormally increased and again cause dilatation of the common duct with resulting right upper quadrant pain. In such an event the symptoms experienced before cholecystectomy may be reproduced. Since duodenal irritation and irritability may be the basic cause of such recurrence of pain, it becomes necessary to seek its causes and to administer appropriate treatment.

Duodenal irritability may be the result of a localized duodenitis or even more frequently part of an irritable colon syndrome so frequently the cause of digestive symptoms. This syndrome is the cause of many of the symptoms of chronic dyspepsia often ascribed to gallbladder disease with which it is very often associated. Duodenal irritability by its effect on gallbladder function may conceivably play a definite part in the stasis of bile within the gallbladder to which Ivy states the formation of gallstones may well be ascribed. Certainly cholecystectomy does not cure an irritable digestive tract and equally certain the symptoms so often ascribed to gallbladder disease will return unless the irritable digestive tract is treated. Secretory abnormalities such as achlorhydria or hyperchlorhydria should likewise be considered in the postoperative regimen. In our experience diverticulosis and irritable colon are often present in association with gallstones.

The period of postoperative convalescence can be ideally utilized to the best advantage of the patient and with the greatest ultimate satisfaction to the physician if all digestive abnormalities receive intensive treatment. Only those relatively few patients with a history of attacks of typical gallstone colic in whom the pain and vomiting are obviously due to transient hypertonicity of the sphincter and dilatation of the ducts with associated pylorospasm and in whom the digestion between attacks is entirely normal should be treated by cholecystectomy and routine postoperative care.

It is necessary in view of our experience to add that the converse of the above is also true that is neither the acute nor chronic peptic ulcer nor in fact the irritable colon can be treated satisfactorily by medical management in the presence of gallstones. Even in those cases in which there have been no attacks of gallstone colic but only the symptoms of irritable colon or of ulcer cholecystectomy should be done if gallstones are demonstrated in order to procure the best results from ulcer or bowel management as well as to avoid the complications of cholelithiasis.

Another observation valuable to us is the fact that in cases of cholelithiasis in which operation was postponed for legitimate reasons the dietary management best adapted to the avoidance of gallstone colic need not be the traditional fat free diet but

may include some fat provided it is not in the form of fried foods. Normal amounts of cream and butter if included in an otherwise easily digestible diet are entirely innocuous and may be included in small quantities even in the diet of the patient treated preoperatively for obesity. These fats may also be included in the postoperative diet of gallbladder patients. The stimulation of cholecystokinin by acid fat contact with the intestinal mucosa need not be avoided if duodenal irritation can be prevented and this is best accomplished by the use of bland easily digestible foods used in the treatment of the irritable digestive tract.

In conclusion the question of *prophylaxis* in gallbladder disease provokes a brief discussion and in this matter also the work of Ivy and his colleagues blazes the trail. Biliary stasis within the gallbladder presumably predisposes to infection and stone formation. Biliary stasis may be due to duodenal abnormalities which result in a hypertonic sphincter of Oddi which fails to relax when the gallbladder contracts. The causative duodenal abnormalities may be of an organic nature such as duodenitis or may be of a functional nature such as the irritable or spastic duodenum. In either case the recognition and treatment of this kind of digestive disturbance may well be a prophylactic measure not only against more serious organic disease in the duodenum such as ulcer but also against disease within the gallbladder.

THE DIFFERENTIAL DIAGNOSIS OF GALLBLADDER DISEASE AND CORONARY HEART DISEASE

DAVID I. RUTLEDGE

HISTORICAL MATERIAL

It has long been recognized that the relationship between gallbladder disease and coronary heart disease is more involved than the problems encountered by differential diagnosis. Babcock³ in 1909 recorded 3 cases of cholecystitis with anginal pain and later discussed the improvement that occurs following surgery. This relationship has been noted by many investigators including Mayo¹², Hamburger¹¹, Schwartz and Herman¹⁰ and others.^{1, 14, 19, 20}

The speculation of various observers as to the probable mechanism of the relationship between the two organs is interesting. At first the bile salts were considered the primary offender. De Mussey⁶ as early as 1878 said that the cardiac murmurs sometimes heard during gallbladder attacks were due to the paralyzing effect of the bile salts. Gangolphe⁹ believed that the cardiac disturbance resulting from gallbladder disease was due to the deleterious effect of the bile salts on the papillary muscle and Fabre⁸ said that myocarditis was due to the accumulation of bile salts in the blood. In 1907 Riesman¹⁶ reported 2 cases of cardiac murmurs heard only during an attack of gallstone colic and suggested that they were due to cardiac dilatation secondary to pain.

As the theory of focal infection gained credence the diseased gallbladder was suspected as a focus. The work of Rosenow²⁷ seemed to indicate more than a casual relationship between disease of the two organs. The clinical observation that the removal of a diseased gallbladder frequently benefited cardiac disease strengthened this view. However a warning note was sounded by Willis¹ when he said that further work was necessary to establish definitely the relationship between disease of the two organs.

The suggestion of a cholesterol diathesis predisposing an individual to concurrent disease in the two organs is interesting but requires further proof before it can be accepted. More recently the work of Gilbert¹⁰ and Owen¹⁵ has indicated that a diseased gallbladder may be the source of reflex action resulting in constrictions of the coronary arteries.

In the differential diagnosis of gallbladder disease and coronary heart disease we need to establish then not only the organ which is causing the particular symptom complex but also whether disease of both organs is present, and if so whether the gallbladder condition is affecting the heart.

PHYSIOLOGY

Before discussing the various diagnostic points it seems wise to review briefly certain basic physiologic facts.

The heart receives its nerve supply from both the vagus and sympathetic nerves. Afferent impulses from the heart are carried by the sympathetic nervous system via the middle and inferior cardiac nerves and their corresponding cervical ganglia, the white rami and posterior roots of the five upper thoracic nerves. Most of the painful impulses from the heart are distributed to the left portion of the first to fifth thoracic segments of the cord. In many persons the distribution seems to be more extensive than this, involving to a limited degree the cervical segments and the thoracic segments down to the ninth.

The afferent impulses from the gallbladder area travel in the right splanchnic nerve to the celiac ganglion from which they are distributed to the thoracic segments of the cord, chiefly on the right. These are distributed chiefly to the eighth to tenth thoracic segments but Ashkenaz has demonstrated that the gallbladder is connected to the central nervous system by afferent pathways which are far more numerous than we were formerly led to believe. He says that the impulses are distributed from the first to twelfth thoracic segments on the right and the fifth to tenth thoracic segments on the left. Somatic nerves connected with these spinal segments determine the zones of the body to which the pain is referred.

Obviously there is overlapping of the segmental distribution of the impulses from the two structures which form the basis for some of the difficulties encountered in the differential diag-

nosis of pain originating in either structure. Recently attention has been centered on certain reflexes which may be equally important.

In 1926 Anrep¹ described a reflex vasoconstriction of the coronary arteries of animals consequent on the increase of intracerebral pressure. It was felt that this was by way of the vagus nerve and was mediated through the carotid sinus. Dietrich and Schweigl, working with von Bergmann,² have demonstrated that distention of the stomach in dogs caused a decrease in coronary blood flow. If hiatus hernia was present also this was more marked and it did not occur after the administration of atropine. Gilbert and Sheridan¹⁰ have shown in animals that a diminution of coronary blood flow can be produced by distention of the gallbladder. This seems highly significant and may explain the improvement reported in coronary sclerosis after removal of a diseased gallbladder. Miller¹¹ suggests that a general autonomic reaction may be set off in disorder of either the gallbladder or coronary arteries which may add further difficulties in distinguishing the origin of pain that may arise as a result of the common afferent pathways.

HISTORY

In the differential diagnosis of gallbladder disease and coronary disease the family history should be investigated. The tendency of both conditions to occur in members of the same family is well recognized. Next it is worth while to consider whether the patient is a fit candidate for either or both conditions. The tendency for coronary disease to occur in men and for gallbladder disease to occur in women is worth remembering. Faulkner and his co-workers⁷ found the ratio of males to females in coronary disease to be 4 to 1 while the exact reverse was true in gallbladder disease. Age likewise is an important diagnostic point. Formerly we were taught that coronary heart disease was a condition of the middle and older age groups. While this is true for women, an ever increasing number of cases of coronary disease in young men is being seen. Recently at the Lahey Clinic a case of unquestionable angina pectoris was observed in a man 21 years of age. Coronary disease is still rare in women under 50 while gallbladder disease is not uncommon. The tendency for gallbladder disease to be more common in women

who have borne children should be remembered Obesity unfortunately is a contributing factor in both conditions

The most important evidence for the differential diagnosis can be obtained from the history of pain

Type of Pain—In both gallbladder disease and coronary heart disease a wide variation in the intensity of pain exists however in gallbladder attacks it is more constantly severe The pain of coronary disease is described as an oppressive or choking sensation while the pain in gallbladder disease is more lincinating in character The pain in coronary disease tends to be constant until relieved, while the pain of gallbladder disease is more colicky in nature A patient in an attack of angina usually remains quiet If the pain is prolonged, as in an occlusion he may seek relief by moving about A patient in an attack of gallbladder colic is apt to thrash about

Location of Pain—The pain of coronary disease is usually located beneath the upper portion of the sternum or if it starts elsewhere it quickly reaches its greatest intensity in this region The pain may appear in the epigastrium throat back or either arm One ordinarily expects the pain in gallbladder disease to start in the epigastrium and spread along the right costal margin however it may be located beneath the lower portion of the sternum or may start in the back When the pain of gallbladder disease appears in other areas of the abdomen it is seldom confused with cardiac pain

Radiation of Pain—The characteristic radiation of pain in coronary disease is down the inside of the left arm Less frequently the radiation is down the inside of both arms or into the throat epigastrium or back When the pain radiates to the back it may be diffusely distributed along the vertebral column rather than localized The pain of gallbladder disease characteristically radiates through to the back well localized in an area near the angle of the right scapula

Precipitating Factors—Pain that consistently can be brought on by effort and relieved at once by rest is almost certain to be due to coronary disease Pain precipitated by emotional disturbances or exposure to cold air is apt to be coronary in origin If the pain occurs at rest and subsides quickly one should think of angina of rest If it persists a coronary occlusion must be considered and other evidence such as an electrocardiogram

may be needed to establish the diagnosis. Pain associated with the taking of food may be due to either condition; however, in coronary disease the pain usually occurs immediately after eating. It usually accompanies what may seem to be an insignificant amount of effort; however, gastric dilatation alone can produce angina. The pain of gallbladder disease is more apt to appear one half to several hours after eating certain types of food such as those high in fat. In angina the quantity of the food is more important than the quality.

Relief of Pain—Pain relieved by rest alone or by the belching of gas is apt to be angina pectoris. The latter pain is probably due to a reflex constriction of the coronary arteries. Pain relieved instantaneously by such vasodilators as nitroglycerin or amyl nitrite is apt to be angina. Whereas these drugs may relieve gallstone colic, relief is seldom as dramatic as in angina pectoris. In coronary occlusion the vasodilators are less apt to be effective. Morphine is usually effective in relieving the pain of either condition. Frequently the administration of oxygen will relieve the pain of coronary disease, whereas it has no effect in gallbladder pain.

Indigestion—Nausea, vomiting and gaseous indigestion may be expected with a gallbladder attack; unfortunately they also frequently accompany coronary thrombosis. One should remember, however, that sometimes nausea and vomiting are the result of morphine given for the relief of pain. If the indigestion is not accompanied by pain and occurs several hours after eating, gallbladder disease is suggested.

PHYSICAL EXAMINATION

Perhaps the most important physical finding is jaundice, since it almost always points to gallbladder disease. Whereas jaundice with coronary disease does occur, it must be regarded as rare unless congestive heart failure has supervened.

In an acute gallbladder attack, one expects to find tenderness and rigidity in the upper abdomen, and for several days after the pain has subsided the findings tend to persist. These symptoms may also accompany coronary occlusion; however, they do not persist as they do in gallbladder disease.

Positive cardiac findings may prove helpful, but all too frequently they are absent. A pericardial friction rub suggests a

myocardial infarct accompanied by pericarditis Gallop rhythm and muffling of the heart tones are suggestive of coronary disease however obesity will also produce the latter A heart murmur is not necessarily significant as far as coronary disease is concerned since this finding has been reported during attacks of gallbladder disease An exception is the aortic diastolic murmur heard in aortic regurgitation on a luetic basis Accompanying this condition there is frequently a narrowing of the coronary vessels at their origin resulting from luetic aortitis which gives rise to anginal pain The presence of tachycardia is not helpful but fibrillation or frequent premature contractions are more suggestive of coronary disease Signs of congestive heart failure point to coronary disease but an enlarged and tender liver may accompany either condition

The general signs of collapse such as sweating falling blood pressure rapid pulse and prostration accompany both conditions Not infrequently patients with coronary infarction develop an ashen gray color which is not ordinarily seen with gallbladder disease Anxiety concerning impending death and psychogenic disturbances are more apt to occur in coronary disease

LABORATORY AIDS

Laboratory examinations may not give much help without the use of electrocardiographic and roentgenologic studies The ordinary procedures such as white blood count and sedimentation rate may be normal abnormal or equivocal in either condition An increased serum bilirubin points toward gallbladder disease

Roentgenologic examination is an invaluable aid Whereas a flat plate of the gallbladder region may not reveal stones the combination of x ray and gallbladder dye such as sodium tetraiodophenolphthalein offers a satisfactory method of determining the status of the organ The revelation of stones or a nonfunctioning gallbladder when the dye is administered by the intravenous route is about 98 per cent efficient The number of diseased gallbladders that present a normal roentgenogram is difficult to determine but Dr Kiefer of the Department of Gastro Enterology of the Lahey Clinic believes that about 80 per cent of diseased gallbladders will present detectable roentgenologic abnormalities

With the advent of the use of chest leads the value of the *electrocardiograph* in coronary heart disease has increased. Wolferth says that he has not seen a case of coronary occlusion proved at postmortem examination without electrocardiographic evidence when chest leads in addition to standard leads have been used. The S T segment and T wave changes are well described and need no repetition here. Occasionally conduction disturbances such as delayed A V conduction or bundle branch block develop as the great majority of these are on the basis of coronary disease this will aid in the diagnosis. The changes ordinarily take place within a few minutes to an hour after occlusion but in case of doubt several tracings should be taken since occasionally the changes are delayed for as long as twenty four hours. It should also be remembered that electrocardiographic changes may be the result of previous trouble and not necessarily indicate that the myocardium has suffered a fresh insult. Serial electrocardiograms are helpful since in a recent infarction there is apt to be variation from day to day. It should be pointed out however that T wave changes have been reported with gallbladder disease. Fitz Hugh and Wolferth have reported 6 cases which showed negative T waves in leads 1 and 2 that became upright following the removal of diseased gallbladders. Since these patients had angina with effort it must be assumed that they had coronary disease but it is entirely possible that the diseased gallbladders were exerting an unfavorable influence on the coronary disease.

COMMENT

Having discussed the points that suggest gallbladder or coronary disease there is still the possibility that both conditions may exist in the same patient and simultaneously give rise to symptoms. The tendency of the two conditions to coexist has been stressed frequently as has also the relief that sometimes may be afforded a patient with coronary disease by the removal of a diseased gallbladder.

If the physician cannot determine definitely whether a given attack is due to gallbladder disease or coronary occlusion he should be content with watchful waiting as a diagnostic and therapeutic aid. There is little danger in delaying surgery for acute gallbladder disease whereas irreparable damage may be

done if surgery is undertaken soon after coronary occlusion. In most instances two or three days will suffice to determine whether a coronary occlusion has occurred.

In conclusion, I should like to emphasize that coronary disease should not be considered a contraindication to surgery of a diseased gallbladder. If it can be demonstrated that congestive heart failure is not present and there has been no coronary occlusion within ninety days surgery can be considered a relatively safe procedure.

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SURGERY IN CASES OF FAULTY VISUALIZATION OR NONVISUALIZATION OF THE GALLBLADDER

MARTIN L. TRACEY

In follow up studies of large series of cases of gallbladder disease the so called chronic cholecystitis the consensus is that surgical treatment in most instances is unsuccessful^{3 4 5} On the contrary the results of cholecystectomy for cholelithiasis justify this procedure unless contraindicated by the patient's general condition

Chronic cholecystitis a condition without reliable diagnostic criteria is difficult to confirm Because the postoperative pathologic report on the gallbladder is seldom negative it is often assumed that the symptoms are caused by the gallbladder However the changes in most gallbladders namely lymphocytic or leukocytic infiltration may be degenerative rather than inflammatory as suggested by Wilkinson⁵ who in 1937 reported a series of 1 032 consecutive cases of cholecystectomy at the Lahey Clinic In 933 of these patients (90 per cent) stones were found

Statistics generally show that 30 to 50 per cent of gallbladder operations are done for noncalculous cholecystitis and post mortem reports show that 66 per cent of persons over 40 have noncalculous cholecystitis¹ many without any symptoms Cattell and Kiefer¹ reported that 90 per cent of patients with stones in the gallbladder had a good result following surgery and that 31 per cent of patients without stones were unimproved O'Donnell⁴ analyzing 7 000 operations for chronic cholecystitis reported over a third as complete failures Jones reviewing O'Donnell's paper, said that gallbladder surgery in such cases is the result of wishful thinking, and that more adequate study frequently will demonstrate that the symptoms are due to simple alteration of gastro intestinal function resulting from faulty bowel habits peptic ulcer colitis hepatitis or urinary tract disturbances

From these considerations it seems important to realize that a visualized homogenous shadow of the gallbladder despite its density size or reaction after a fat meal should be ignored at least temporarily. Such variations in density size or reaction to the Graham test should not constitute a stimulus for early surgery but indicate the need for further study. Too many factors affect the concentration of dye in the gallbladder and its emptying to justify the faulty visualization with the Graham test as the important criterion for operation.

When the physician is confronted with a patient with chronic indigestion who has had a faulty visualization of the gallbladder in the absence of biliary colic or jaundice several factors should be checked. Since the oral method is generally used for practical purposes it is wise to find out whether the patient took the dye and how it was retained. Vomiting before forty minutes after ingestion of the dye will usually interfere with obtaining a roentgen ray shadow. Diarrhea from the dye will occasionally interfere with visualization. Sometimes patients in their consciousness of present disturbances forget past symptoms which might bear on visualization of the gallbladder. Careful re inquiry may reveal a history of peptic ulcer. Severe attacks of long forgotten pain might mean biliary colic or perforation of a viscus by a gallstone with production of an internal biliary fistula. Past operations should be rechecked especially in the presence of upper abdominal scars. If surgery was performed elsewhere communication with the surgeon may be necessary as patients are not always sure whether the gallbladder was removed.

In questionable instances a barium study of the stomach small intestine and colon even though negative for organic disease will give valuable information. Not infrequently duodenal ulcer and rarely an internal biliary fistula will be demonstrated and provide valuable information affecting gallbladder visualization. Liver function tests may add credence to a suspicion of hepatic disease. Medical treatment sufficient to control such factors as affect gallbladder visualization especially peptic ulcer and faulty bowel habits with cathartic excess will allow visualization of the gallbladder. The adequacy of treatment must be left to the clinical judgment of the physician but it need not be longer than five to ten days.³ In the recheck after treatment the gallbladder dye should be given intravenously unless contraindicated.

cated to eliminate the indefinite factors of ingestion and absorption in the oral method

The length of treatment of allied conditions should not be long, because of the risk of unnecessary delay. Patients with stones silent or causing colic and patients with rechecked nonvisualization of the gallbladder without demonstrable cause should be operated upon early because of the subsequent unpredictable possibility of an acute inflammatory process in the biliary tract, liver damage with repeated colic, pancreatitis, jaundice and biliary obstruction. If the gallbladder contains stones or is suspected of containing stones or being infected, the patient should be urged to have a cholecystectomy under favorable conditions rather than to wait in acute attack requiring an emergency operation. If the patient elects to delay surgery, the responsibility should be placed on the patient and the relatives.³

A dull right upper quadrant pain or ache associated with flatulent indigestion is often a separate entity. Questioning may elicit the fact that such pains are muscular, aggravated by posture, motion and occupation and improved by rest, change of position, vacation or other changes in habits. Neurologic examination, roentgenologic examination of the thoracolumbar spine and pyelograms may yield a diagnosis. Faulty visualization and even nonvisualization associated with such myalgias, spondylitis, arthritis and fibrositis are often functional and rechecked of the Graham test will show a normal response after treatment of the functional indigestion or nonbiliary digestive affections.

CONCLUSIONS

Dysfunction of the gallbladder after a fat meal and nonvisualization in the absence of biliary colic or jaundice do not indicate a need for immediate decision as to surgery. Cholecystographic criteria often change after brief treatment of indigestion of nonbiliary origin. Failure to diagnose and treat coexisting disturbances is often the cause of a faulty visualization with the Graham test; such failure to appraise coincidental affections results in recurrent or persistent trouble after cholecystectomy, the so called postcholecystectomy syndrome. Since results of cholecystectomy for noncalculous cholecystitis have been generally poor with faulty Graham tests in the absence of biliary

colic or jaundice the following criteria for surgery are deemed proper³

- 1 Elimination of all other causes for symptoms
- 2 Sufficient pain to warrant relief by surgery
- 3 A highly suspicious rechecked Graham test
- 4 Lack of relief by medical treatment of suspected or confirmed coexisting digestive disturbances

Such careful evaluation would result in better results in gall bladder surgery fewer operations for noncalculous cholecystitis with less trouble postoperatively from overlooked functional indigestion. This plan restricts gallbladder surgery almost entirely to patients with stones, acute inflammatory processes and nonvisualization or faulty visualization independent of external factors. It will aid in separating those digestive syndromes often attributed to gallbladder disease per se but remediable by treatment of gastric or intestinal particularly colonic dysfunction which often accounts for faulty or nonvisualization with the Graham test.

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PREPARATION OF THE JAUNDICED PATIENT FOR OPERATION

RALPH ADAMS

No medical subject has stimulated more thought and been productive of more brilliant discoveries than the care of the jaundiced patient. For a half century the frequency of lesions causing biliary tract obstruction with corollary jaundice has been a challenge to perfection of surgical procedures applicable to the biliary tree. Although by 1930 surgery of biliary disease had achieved a high degree of excellence and standardization jaundiced patients continued to die in disturbing numbers either during or shortly after operation. The principal reasons for death were hemorrhage, evisceration, pernicious vomiting and diarrhea, intestinal atony and distention or the so called hepatorenal syndrome. Inadequate knowledge concerning the principles of nutrition was responsible for much of the morbidity and mortality. From biochemical and experimental animal research has come new knowledge of nutritional processes which alert clinicians have been quick to apply to preoperative preparation with the result that surgery on seriously ill jaundiced patients has become relatively safe.

The purpose of this article is to record the program by which jaundiced patients at the Lahey Clinic are now prepared for operation. Whether the jaundice is hemolytic, toxic, infectious or obstructive in origin is not pertinent to the problem under discussion except as it may alter details in preoperative preparation. Familial hemolytic jaundice with a large spleen, alcoholic cirrhosis with carcinoma of the sigmoid, catarrhal jaundice with a coincidental surgical problem, common duct obstruction caused by stone and carcinoma of the ampulla of Vater have in common the feature of jaundice and the probability of liver damage. If the hazards inherent in the jaundiced state can be controlled preoperatively the risk of operation is reduced essentially to that of the underlying disease.

LABORATORY TESTS

Although clinical observation seasoned by experience is the most important guide in deciding when a patient is ready for operation laboratory tests yield valuable objective data on the physiologic status and when such tests are repeated at intervals during the period of preparation they indicate the rate of response to therapy. Almost routinely the following laboratory data are recorded: (1) complete blood count (2) urinalysis including tests for bile (3) nonprotein nitrogen chlorides serum protein serum bilirubin levels, blood grouping Hinton reaction prothrombin time and hematocrit (4) hippuric acid bromsulfalein and Takata Ara tests (5) stool examination for urobilin (6) on occasion cholesterol quantitative van den Bergh cholesterol cephalin flocculation test albumin globulin ratio glucose or galactose tolerance test and (7) cholecystogram.

EVALUATION AND THERAPY

The program of treatment is designed to achieve two basic objectives: (1) protect or restore the ability of the liver to synthesize, store and mobilize glycogen, elaborate prothrombin and form bile and (2) maintain kidney function.

Diet

The first essential in treating a damaged liver is adequate carbohydrate intake. Without an abundant supply of carbohydrate glycogen cannot be synthesized and without glycogen the detoxifying and reformative processes of the liver are severely handicapped. In the absence of sufficient carbohydrate the liver stores fat and is reduced in efficiency. An excess of dietary fat may accentuate existing damage by accumulating in the liver for lack of glycogen to complete its combustion. Chronic alcoholism and lack of vitamin B also lead to storage of fat in the liver. Protein metabolism is connected intimately with liver function particularly in the detoxifying processes by which the organism is protected from noxious agents including anesthetics. In spite of the well known protein sparing action of carbohydrate it has been recognized in recent years that moderate quantities of protein are beneficial especially when the jaundice is of the obstructive type. Apparently the proteins of milk and eggs are more beneficial than those of meat.

Determinations of serum protein percentage albumin globulin

ratio and cholesterol level are helpful in deciding upon the diet required to offset the disturbed metabolism of fat and protein. Usually a high carbohydrate moderate protein low fat diet is needed. Using as an example a patient with marked nutritional deficiency weighing 155 pounds (70 kg) such a diet may be expressed in three ways: (1) carbohydrate 75 per cent protein 20 per cent fat 5 per cent and calories 3,600; (2) carbohydrate 9 protein 3 and fat 0.5 gm per kilogram of body weight and (3) carbohydrate 630 gm protein 210 gm, fat 35 gm and calories 3,675.

This diet is based on the principle of giving enough carbohydrate to prevent protein loss, enough protein to effect liver regeneration and repair, and little enough fat to prevent liver storage. It is varied in accordance with individual requirements. The fat content is rarely raised above 5 per cent, but the percentage of carbohydrate may be reduced as low as 50 and that of protein raised as high as 45. If the carbohydrate intake falls below 300 gm, 10 or 20 per cent glucose is given as intravenous supplement. Proceeding on the theory that intravenous glucose solution provides an incentive to glycogen formation, all jaundiced patients preoperatively are given at least 1,500 cc (usually 10 per cent) of glucose solution daily, even though the oral carbohydrate intake may be satisfactory.

Insulin is not used unless actual diabetes exists. The proposal for its use in the nondiabetic patient was based upon resulting increased glycogen storage. However, the insulin induced storage of glycogen may be more marked in the muscles than in the liver where it is most needed. The administration of insulin on evidence of a low glucose tolerance curve alone is also unsound without collateral evidence of actual diabetes, because the damaged liver may cause high, low or variable blood sugar readings and effective glycogen formation still proceeds if adequate carbohydrate intake is assured. If the protein intake falls below 100 gm, supplement is provided in the form of protein concentrate transfusions or intravenous amino acid therapy.

Bile Salts and Vitamins

Failure of delivery into the intestinal tract of suitable quantities of the bile constituents, notably the bile salts, results in

faulty absorption of essential vitamins or their precursors into the blood stream. Vitamins A, D, E and K, being fat soluble, require the presence of bile salts before they may be absorbed through the intestinal wall. Therefore the hemorrhagic diathesis, skeletal decalcification or night blindness resulting from deficient absorption may be expected in chronic advanced liver disease, biliary fistula or common duct obstruction. It should be remembered that clinical jaundice is not necessarily a feature of either chronic liver disease or biliary fistula and that the jaundice of common duct obstruction bears a coincidental but not causative relationship to the hemorrhagic diathesis. Bilirubin by its mere presence in the blood has no adverse effect upon the clotting mechanism but its estimation is of value in determining the intensity of jaundice and to some extent its duration. Together with quantitative determinations of the urinary urobilinogen output, the serum bilirubin estimation can be used to measure the extent of injury to the liver and if the biliary obstruction is complete, the efficiency of renal function. The latter can be determined by test of stool urobilin daily over a three day period or by search of the duodenal contents for bile constituents.

Although concentration of bile salts may be estimated by study of duodenal contents, that of vitamin A by biophotometer readings of dark adaptation, that of vitamin D indirectly by skeletal roentgenograms or calcium and phosphorus values, the reasonable, convenient and accepted method of establishing failure of fat soluble vitamin (specifically vitamin K) absorption is by determination of the plasma prothrombin concentration. If subnormal percentages are found, a water soluble derivative of 2-methyl-1,4-naphthol quinone is given parenterally daily in 3 to 6 mg quantities until normal values are established and continued at intervals of two days as necessary to maintain an adequate level. A transfusion of fresh blood (whole or citrated but not bank preserved) will often have a dramatic effect in stopping hemorrhage due to lack of vitamin K, because of the vitamin K content of the transfused blood. The response is transitory and rarely lasts more than twenty-four hours but as initial therapy it is important for not only is vitamin K made immediately available but depletion of blood cellular elements is corrected. Oral administration of vitamin K or bile salt prepara-

tions is not necessary when vitamin K is given parenterally however bile salts (15 gm daily are sufficient) are given by mouth as are concentrates of vitamins A D and K if the preparatory period is to be more than a few days in length If the jaundice is obstructive in origin bile salts are withheld or given sparingly until after release of the obstruction because of possible further injury to the liver and kidneys after absorption into the blood

The water soluble vitamins B and C are also prescribed in quantities well in excess of estimated minimal requirements The jaundiced patient like the debilitated one is likely to suffer in some degree from multiple avitaminosis Such therapy materially reduces the incidence of complicated wound healing and post-operative atony vomiting and distention

Fluid Balance

The grave danger of the immediate postoperative period in patients with obstructive jaundice is acute hepatic and renal failure signaled by oliguresis rising nonprotein nitrogen hemoglobin concentration fever and edema with abnormalities in the blood electrolytes Once underway the process is refractory to treatment is likely to be irreversible and usually ends fatally In the preoperative period every effort must be made to forestall such a complication To this end frequent determinations of the nonprotein nitrogen serum protein, plasma electrolytes hemoglobin and hemoglobin as well as the urinary volume albumin and sediment content are obtained Plasma or whole blood transfusion intravenous amino acids, glucose in 5 per cent concentration in saline or distilled water are used persistently as indicated until physiologic fluid protein and electrolyte balance are attained

If the hepatic and renal reserves have been permanently destroyed by disease or an emergency forces operation these details of preparation are sometimes impossible to achieve but the effort must be made in every case

ANESTHESIA FOR BILIARY TRACT SURGERY

MORRIS J. NICHOLSON

THE primary consideration in selecting an anesthetic for any operation should be the safety and comfort of the patient but when a biliary tract operation is contemplated the anesthetic should provide in addition the best possible operating conditions. This is true because such an operation is difficult and dangerous requiring good exposure for its safe performance. The anatomy in the region of the biliary tract makes good exposure difficult. The bony framework of the lower chest wall and the bulk and immobility of the liver plus its peculiar shape all help to obscure the operative field. The close proximity of the colon and stomach adds to the surgeon's difficulties. Maintenance of adequate exposure is trying as most of these operations are carried out in a deep hole the sides of which are kept in constant motion by the excursions of the diaphragm. The anesthetic can therefore facilitate the operation by providing good *muscular relaxation*.

In an attempt to keep the mortality and morbidity of biliary tract operations at a minimum the Medical Surgical and Anesthesia Departments of the Lahey Clinic have found it essential to pay strict attention to many details of the hospital management of these patients.

In this paper these details will be discussed under the following headings: preoperative preparation, premedication, choice of anesthetic agent and method, operative and postoperative course.

PREOPERATIVE PREPARATION

To evaluate properly the preoperative preparation and anesthetic risk of a patient about to have a biliary tract operation the anesthetist must be familiar with the many details of preparation in modern therapeutics. Many patients with biliary tract disease present certain irreversible pathologic changes such as arteriosclerosis and hypertension. To reduce to a minimum the complications generally associated with biliary surgery one must be sure that the reversible pathologic changes have been treated.

adequately. The obese patient should be reduced, vitamin deficiency vigorously treated with vitamins A, B complex, C and K, and diabetes brought under control. Dental caries and oral sepsis should be corrected, respiratory and urinary tract infections eliminated, and abnormal blood findings returned to normal through the use of iron, liver and transfusions. Most important of all is an attempt to repair the damaged liver by feeding a high carbohydrate, high protein, low fat diet.

Adequate preparation of the jaundiced patient is quite complex. The prothrombin time should be made to approach 100 per cent of normal by the intravenous use of vitamin K and oral administration of bile salts. Complete obstruction of the biliary passages by stone, injury or pancreatic carcinoma makes even more intensive preparation necessary. A reversal of the albumin globulin ratio may exist along with a reduction of the serum protein. Treatment consisting of a high protein diet, intravenous amino acids and blood plasma should be instituted to return the serum protein to between 6 and 8 gm per 100 cc.⁵ Reestablishment of this delicate protein balance is very important for without it the patient is always on the borderline of shock.

When an external biliary fistula is present, abnormal blood calcium and phosphorus levels are to be expected. These generally can be corrected by the use of vitamin D and intravenous and oral administration of calcium.

A relative idea of the amount of liver damage can be obtained by the bromsulfalein or hippuric acid liver function test. Failure of the liver to remove all of the bromsulfalein from the blood by the end of one hour indicates liver damage but not the type or degree. The intravenous hippuric acid liver function test consists of the intravenous injection of 1.77 gm of sodium benzoate dissolved in 20 cc of water. The urine is collected at the end of one hour and the hippuric acid content determined. The normal excretion is 1 gm or 0.7 gm of hippuric acid equivalent of benzoic acid.

In order to establish a base line from which to gauge improvement of the obstructed liver, the serum bilirubin should be obtained and compared with the normal bilirubin of 0.5 mg per 100 cc of serum. To foreshadow the possibility of a postoperative hepatorenal syndrome, the nonprotein nitrogen should be determined and, if elevated, returned to normal.

Intravenous glucose is helpful in restoring the damaged liver to normal but more emphasis should be placed on the feeding of an adequate protein diet. An adequate protein diet not only protects the liver from a variety of hepatotoxic agents but also is more efficient than carbohydrate in reducing the concentration of hepatic lipid in the presence of ductal obstruction.⁸

The reaction of a jaundiced patient to an anesthetic or operation is so unpredictable that routine scheduling for a transfusion is wise. Intravenous fluids should be started in the operating room before surgery.

PREMEDICATION

Preoperative medication should be given to allay apprehension, reduce metabolic activity and produce a certain amount of amnesia. Usually these results can be obtained through the administration of varying doses of pentopon, scopolamine and a short acting barbiturate. A healthy, vigorous patient under 50 years of age generally is given pentopon $\frac{1}{4}$ grain and scopolamine $\frac{1}{150}$ grain subcutaneously two hours before operation and 3 grains of a short acting barbiturate orally one hour before operation. These dosages are reduced for older and weaker patients and a patient over 60 is not given a barbiturate. It is safer to err on the conservative side in ordering preoperative medication for a patient with liver disease because additional medication can be given so easily by the intravenous route in the operating room.

Jaundiced patients should be given only small doses of opiates and no barbiturates and patients who are suspected of having severe liver damage should receive no preoperative medication. One should be on guard when a jaundiced patient fails to show improvement in the prothrombin time after receiving adequate vitamin K. In our experience this indicates severe liver damage and even small doses of premedication may cause profound narcosis or coma.

On several occasions shortly after the patient received opiates in preparation for biliary operation there was epigastric or substernal pain almost indistinguishable from the pain of coronary thrombosis or angina pectoris. Raydin and others¹⁵ have shown that reflexes arising in the distended common duct may give rise to pain simulating angina pectoris. Our clinical im-

pression is that the opiates often cause a spasm of the sphincter of Oddi with resulting increased pressure in the common duct which sets up the reflex pain simulating coronary disease. On careful questioning many patients describe similar attacks which occurred after the use of opiates for the relief of pain.

CHOICE OF ANESTHETIC AGENT AND METHOD

In 1907 Ravdin¹⁴ said: "The choice of the proper anesthetic for patients with hepatic insufficiency is of the greatest importance. It has been well established for many years that chloroform should not be used in these patients. We have good evidence that ether also can cause severe damage in the presence of anoxemia. Because of the slowing of the vascular stream in ductal obstruction there is local anoxemia of the liver tissue. Some of the violent postoperative reactions after the use of ether are without doubt due to the damage of the liver cells."

Spinal anesthesia has little or no deleterious effect on the liver or kidneys provided adequate blood pressure and oxygenation are maintained. Under spinal anesthesia the secretion of bile and urine goes on uninhibited throughout the operation but this is not true under ether.

Our policy for some years has been to use some form of spinal anesthesia for all biliary tract operations. The profound muscular relaxation and quiet breathing provided by spinal anesthesia facilitate the surgeon's work while the freedom from possible harmful effects on the liver and kidneys is advantageous to the patient. In 1935 Sise¹⁷ reported the use of *pontocaine glucose mixtures* for the production of spinal anesthesia for biliary operations. The underlying idea of this method is to make the anesthetic solution always heavier than spinal fluid so that after injection the force of gravity will cause it to flow in any desired direction in the spinal canal. Early in the use of this technic it was clearly shown that the height of anesthesia could be controlled and the longer duration offered by pontocaine obtained. This continues to be our routine selection for uncomplicated biliary crises (Fig. 154). For the longer more complicated biliary operation such as repair of common duct injury (Fig. 155) or removal of pancreatic carcinoma (Fig. 156), we now use *fractional* spinal anesthesia. Supplementary cyclopropane anesthesia may be given in conjunction with the

LAHEY CLINIC ANESTHESIA RECORD

Name Female Age 42 Wt 187 lbs Date 9/5/42 Race Baptist Religion 211

Pre-op Temp 98.6 Rectal Temp 98.6 Throat Temp 98.6 Pulse 100 Respiration 20

Position Supine

Pre-medication None

Induction None

Maintenance None

Termination None

Notes: Spinal lumbar puncture L3-L4 (2 Dec 12) Pontocaine + 2% 10% dextrose injected at 4 cc. 1 sec. a pt. in 10 Trandelenburg position Table level after 1 minute Anesthesia to T5 in 1 to 4 minutes

Diagnosis: Cholecystitis & Cholelithiasis

Operation: Cholecystectomy - Appendectomy

Signature: [Signature]

Fig 154—Illustrative anesthetic record of case in which pontocaine-glucose spinal anesthetic was used for cholecystectomy and appendectomy. Note fall in blood pressure associated with traction on gallbladder.

spinal anesthesia when necessary to control apprehension or discomfort. Any patient who so desires may be put to sleep as soon as the spinal anesthesia is induced.

SPINAL ANESTHESIA—OPERATIVE COURSE

When the patient comes to the operating room for a cholecystectomy, a blood pressure apparatus is strapped on one arm

This bar enables the anesthetist to raise the patient's head as desired and also acts as a brace to the lower shoulder thus preventing him from sliding toward the head of the table when

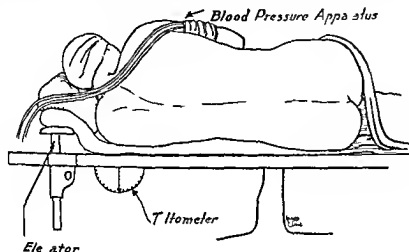


Fig. 157—Patient in position for spinal puncture when pontocaine glucose mixture is to be used

it is lowered. If such a bar is not available the head may be placed on a hard pillow or sand bag and shoulder braces used to keep the patient from sliding when the table is tilted.

The previously estimated dose of pontocaine (tabulation) is drawn into a 5 cc syringe. To this is added 10 per cent glucose

TABLE FOR DETERMINING DOSE OF PONTOCAINE
FOR SPINAL ANESTHESIA IN ADULTS

	Pontocaine mg.	10% Dextrose cc	Position of Injection	Head Position
Anus and perineum	10	1 (1 cc spinal fluid)	10 degree Fowler	Elevated
Lower extremities lower abdomen	10-14 14-16	1.5-2.1 2.1-2.4	Leel 10 degree Trendelenburg	Elevated Elevated
Upper abdomen	16-20	4-3-0	10 degree Trendelenburg	Elevated

in volume equivalent to one and one half times that of the pontocaine. This solution is thoroughly mixed. With the patient's head raised as much as is comfortable on the goiter bar the

spinal puncture is made in the third lumbar interspace and the table is slanted with the head downward at a 10 degree angle (Fig 158 a) Injection of the solution is made slowly with the patient in this position approximately 15 seconds being required. The patient is immediately turned on his back and the goiter bar is raised a little higher. One minute from the time the injection was started the table is raised to a level position.

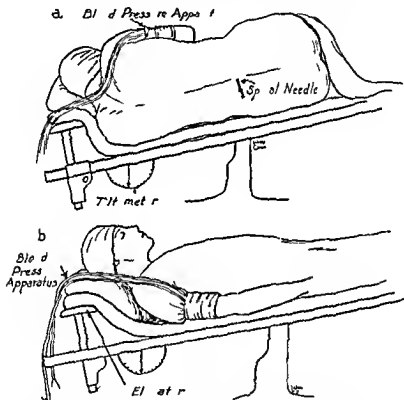


Fig 158—*a* Patient in position for injection of pontocaine-glucose mixture for spinal anesthesia *b* Position for obtaining height of anesthesia

tion. Of course the table will have been leveled off earlier if on testing the patient the anesthesia was found to have reached sufficient height that is the fifth thoracic segment. With the table level a second testing of the anesthesia is immediately carried out. The combination of raising the head and slanting the table downward produces a marked concavity in the upper part of the thoracic region into which the heavy solution flows

and tends to collect. The upward slant of the upper thoracic and cervical regions generally stops further progress cephalad of the anesthetic (Fig 158, *b*).

If the height of the anesthesia is unsatisfactory, correction is made by adjusting the position of the patient. If the height of the anesthesia is more than two segments lower than desired, the head of the table may be tipped downward 5 degrees for another minute. If the anesthesia is within two segments of the desired height, it will probably move up a little farther without lowering the head of the table. When the anesthesia has gone up too high, the head of the table should be raised promptly to a 5 degree Fowler's position to prevent further cephalad flow of the anesthetic mixture. This maneuver will not immediately lower the height of the anesthesia, but it will lessen its intensity and shorten the duration. The blood pressure and respirations of the patient should be closely watched so that the anesthetist may be forewarned of any untoward reaction. Most fatal reactions resulting from spinal anesthesia alone occur during the first thirty minutes.

Fractional Spinal Anesthesia

For the longer, more difficult operation, fractional spinal anesthesia is employed, and the special equipment described by Lemmon⁹ is required (Fig 159 *a, b, c, d*). A new type introducer designed by Moore¹¹ (Fig 159 *f*) through which the soft malleable German silver needle may be inserted and the introducer removed without dislodging the needle is a helpful addition to this equipment.

The pontocaine-glucose solution used for fractional spinal anesthesia consists of 4 cc of 1 per cent pontocaine in normal saline and 6 cc of 10 per cent glucose, making a 0.4 per cent solution of pontocaine in 6 per cent glucose (1½ parts glucose to 1 part pontocaine). The 30 inch length of tubing with a capacity of 2 cc is filled with the anesthetic solution, leaving 8 cc in the syringe.

The patient is placed on a special mattress in the left lateral decubitus position so that the back is toward the side of the mattress containing the opening. The second or third lumbar interspace is anesthetized with the ephedrine-pontocaine mixture. The long Sise introducer (Fig 159 *e*) is passed through the

spinal puncture is made in the third lumbar interspace and the table is slanted with the head downward at a 10 degree angle (Fig 158 a) Injection of the solution is made slowly with the patient in this position approximately 15 seconds being required The patient is immediately turned on his back and the goiter bar is raised a little higher One minute from the time the injection was started the table is raised to a level posi

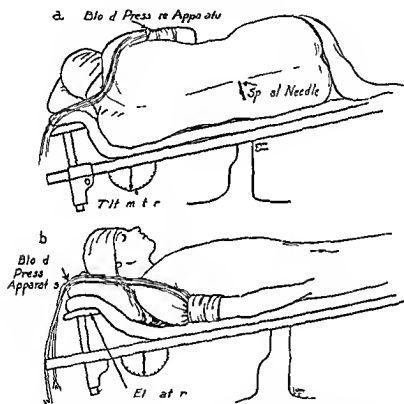


Fig 158—*a* Patient in position for injection of potassium glucose mixture for spinal anesthesia *b* Position for obtaining height of anesthesia

tion Of course the table will have been leveled off earlier if on testing the patient the anesthesia was found to have reached sufficient height that is the fifth thoracic segment With the table level a second testing of the anesthesia is immediately carried out The combination of raising the head and slanting the table downward produces a marked concavity in the upper part of the thoracic region into which the heavy solution flows

syringe is forced out by the cerebrospinal fluid pressure before the spinal fluid can be easily aspirated into the tube the spinal puncture is satisfactory. The patient is turned supine and placed in a 10 degree Trendelenburg position. 3 cc (10 mg) or 4 cc (16 mg) are injected at the rate of 0.25 cc per second (Fig

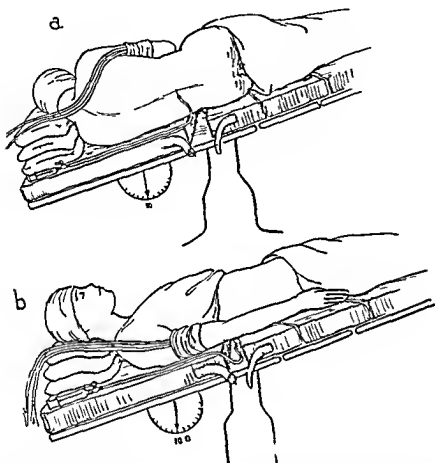


Fig 160—*a* Position of patient for injection of pontocaine glucose mixture for fractional spinal anesthesia when injection is made prior to turning the patient supine *b* Position of patient for injection of pontocaine glucose mixture for fractional spinal anesthesia when injection is made after patient is turned supine

160 *b*) When this method is used frequent careful testing enables the anesthetist to watch the progress of the anesthesia upward. After 4 to 8 minutes anesthesia usually extends to the fourth thoracic interspace and the patient is turned level.

If the initial injection of pontocaine glucose is made with the patient in the 10 degree Trendelenburg position but before he is

turned supine (Fig 160 a) anesthesia will develop more rapidly (1 to 7 minutes). When this modification is used the technique is the same as for the conventional pontocaine glucose spinal anesthesia except that the injection is made after the tubing and syringe are connected. The same precautions with regard to early and frequent checking of the height of anesthesia elevation of the head and not leaving the patient in the head down position for over one minute should be observed.

After one hour the stopcock on the Luer Lok connection at the syringe is opened and the spinal fluid allowed to flow into the syringe in an amount equal to that remaining in the syringe and tubing so that each cubic centimeter contains 2 mg of pontocaine. Subsequent injections of 2 to 5 cc (4 to 10 mg) are made as needed with the patient in the level position.

This method of anesthesia has proved satisfactory for operations requiring as long as four hours.*

The use of the gallbladder lift or semi Fowler's position as a means of improving exposure often has a deleterious effect on the blood pressure. If either of these adjuncts is to be used the blood pressure should be watched carefully.

During operation under spinal anesthesia a characteristic fall in blood pressure associated with traction on the gallbladder liver and common duct is sometimes observed. The systolic blood pressure may fall from 20 to 50 points but generally little or no change in the respiratory rate or pulse rate occurs. There seems to be little difference in severity of these reactions in the conscious patient and the one rendered unconscious with cyclopropane (Fig 154). In general the blood pressure tends to return to normal with removal of traction but if not the blood pressure usually can be returned to normal by the subcutaneous injection of a mixture of 25 mg of ephedrine and 5 units of pitressin.¹⁰

POSTOPERATIVE COURSE

The significant decrease of pulmonary ventilation which has been repeatedly demonstrated following upper abdominal operations predisposes these patients to postoperative pulmonary complications.^{4, 13} Patients who have aspirated blood mucus or

*For more complete details regarding spinal anesthesia used at the Lahn Clinic see reference 16.

other material should be submitted to tracheobronchial aspiration before leaving the operating table. This can be done by suction bronchoscopy or simply passing a No. 22 F. ureteral catheter into the trachea and applying suction as it is withdrawn. It is extremely important that the patient be returned to his room with a clear airway. Morphine should be used sparingly and deep breathing and coughing in moderation encouraged. A tight binder that restricts expansion of the costal margin and prevents aeration of the lower lobe should not be used. Starr and Gilman¹⁸ have shown that bilateral intercostal nerve block by the method of Bartlett³ gives relief of upper abdominal wound pain. This relief of pain encourages the patient to breathe deeply, cough freely and move about in bed. If in spite of these preventive measures the patient shows signs or symptoms of atelectasis which are confirmed by roentgenogram, he should have bronchoscopic examination immediately. Eversole⁶ and Mousel¹ have shown that early bronchoscopy is generally followed by reexpansion of the involved area and pneumonitis or pulmonary suppuration is prevented.

In an attempt to prevent postoperative phlebitis and pulmonary embolus we have used pressure bandages to obliterate superficial varicosities in the lower extremities.⁷ When this is done before and after operation it increases the blood flow in the deep venous system and thus tends to diminish the possibility of thrombosis in both the superficial and deep veins. In addition all patients are given bicycle exercises three times a day postoperatively to prevent circulatory stagnation. These measures are carried out with the hope of preventing thrombus formation in the deep veins of the calf muscles where so many fatal emboli originate.

Because of the work of Barker¹ we are careful of those patients who have residual findings of a previous thrombophlebitis. In 46 cases with a history of thrombophlebitis occurring less than one year prior to operation he found that 31 had some type of pulmonary embolus postoperatively. Fifteen of these were fatal. Because of this increased risk it would seem that some anticoagulant (heparin, dicoumarin) should be used during the postoperative period to protect these patients from a possible fatal pulmonary embolus.

It is not unusual to find a patient whose main problem after

cholecystectomy seems to be an accumulation of tracheal secretion but who is actually suffering from gastric dilatation. The secretions heard in the trachea have gradually leaked out of the distended stomach through the esophagus and into the pharynx to be aspirated. To treat such a patient properly his stomach must be emptied by Levin tube and then the material removed from the trachea by aspiration.

Fluid balance must be well controlled in all postoperative patients particularly in those having a stormy recovery from biliary surgery. Intravenous glucose and saline must be given as well as blood and plasma as indicated. Parenteral vitamin administration is important particularly vitamin K.

No one likes to think of a postoperative wound disruption with evisceration but they do occur and they must be dealt with. Spinal anesthesia provides ideal relaxation for the repair of these disrupted wounds.

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INDICATIONS FOR EXPLORATION OF THE COMMON BILE DUCT

RICHARD B. CATTELL

DURING the four year period of 1938 to 1941 inclusive 909 patients with gallbladder disease were operated upon at the Lahey Clinic. Common duct exploration was carried out in 444 patients (48.8 per cent). Common duct stones were found in 178 patients or 14.1 per cent of all gallbladder patients operated upon during this period. These figures demonstrate the importance of common duct exploration in our management of patients with gallbladder disease. In order that a true picture be presented it should be added that approximately 96 per cent of gallbladder patients operated upon have stones. For in recent years few patients with noncalculous disease have been submitted to surgical treatment.

The question might properly be asked: Why is it necessary to explore the common duct in approximately one half of all patients operated upon for gallbladder disease? At the Lahey Clinic we believe there is no group of symptoms or physical findings either before or at the time of operation which can serve justly to exclude the presence of stones in the common bile duct. In an earlier review a number of patients who had cholecystectomy were found to have recurrence of symptoms due to common duct stone. At that time the incidence of common duct stone in our gallbladder cases was approximately 8 per cent in contrast with the present incidence of 14.1 per cent. After exploring over 1700 common ducts we are satisfied that exploration of the common bile duct does not increase the operative mortality. Furthermore it does not lead to late complications such as stricture formation at the site of exploration. This procedure possibly may add one to three days to the hospital stay, but even this is unnecessary for patients without positive findings in the common duct. The routine employment of spinal anesthesia for biliary tract procedures has certainly facilitated

not only removal of the gallbladder but also adequate exposure and exploration of the common duct as indicated

At the Clinic we do not recommend or practice the routine exploration of the common duct in all gallbladder cases nor do we recommend frequent exploration of the common duct unless the surgeon's experience is such that the procedure can be carried out with reasonable facility and safety. Exploration certainly should not be done if the operating conditions are unsatisfactory. In such instances it is better to leave the common duct disease until a later operation than to jeopardize the duct.

In this discussion I will present our experience at the Lahey Clinic with particular reference to the indications we use for common duct exploration.

INDICATIONS

- 1 Past or present history of jaundice
- 2 Elevated serum bilirubin subclinical jaundice
- 3 Dilated or thickened common duct
- 4 Unsatisfactory or suspicious findings on palpation
- 5 Small stones in the gallbladder with a patent cystic duct
- 6 Sediment in aspirated common duct bile
- 7 Acute or subacute pancreatitis or hepatitis
- 8 Acute cholecystitis

Jaundice—Jaundice is a definite indication for common duct exploration and its degree or depth makes little or no difference. In many cases the jaundice fades or disappears preoperatively and even though the history given by the patient leaves some doubt as to whether jaundice actually existed exploration should be performed. The occurrence of jaundice many years before the time of operation as a single incident probably is not indicative of common duct disease but in these cases too exploration is advisable. If at operation on a deeply jaundiced patient a definite malignancy is demonstrated in the head of the pancreas it may be proper to avoid exploration of the common duct and perform a cholecystojejunostomy. In our experience with removal of common duct stones 61 per cent of the patients have some degree of jaundice. It is not commonly appreciated that as high as 39 per cent or two fifths of all patients with common duct stone do not have jaundice. For this reason the surgeon should realize that while jaundice is a positive indi-

cation for exploration its absence by no means is an assurance that common duct stones are not present.

Elevated Serum Bilirubin—Other patients, a smaller group who have never had jaundice show laboratory evidence of partial obstruction of the common bile duct. In the routine investigation of gallbladder cases a determination of either the icterus index or the serum bilirubin is made. In a large group of cases the normal value of serum bilirubin was found to be 0.7 to 0.3 mg per 100 cc. The concentration in the blood of 0.7 mg or more of bilirubin per 100 cc is necessary to produce an icteric tinge to the scleræ or mucous membranes and approximately 1 mg per 100 cc to produce icterus of the skin. A number of conditions outside the biliary tract are capable of giving elevation to the serum bilirubin to what we term the subclinical jaundice level, yet we consider elevation to be sufficient indication for exploration of the common duct.

Dilated or Thickened Common Duct—Visual and probable changes in the hepatic and common bile ducts are fairly frequent in gallbladder cases. In our routine cholecystectomy the gastrohepatic omentum is incised and spread to visualize both hepatic and common bile ducts so that dilatation is readily demonstrable. There is a physiologic dilatation of the common bile duct following cholecystectomy and if the cystic duct is obstructed this same dilatation will exist whether or not there is common duct disease. In the majority of patients having common duct stone some dilatation will be present and for this reason all patients having dilatation should be explored. Other physical changes in the main bile duct may be indicative of trouble. Patients with cholangitis and some with long standing chronic inflammation of the gallbladder will have a similar thickening of the ducts. Exploration and prolonged drainage particularly in those patients having cholangitis are indicated. Chills and fever with intermittency of symptoms and associated with common duct stone have been observed only on rare occasions. These symptoms which are described so frequently in the older literature occur in approximately 5 per cent of our patients with common duct stone.

Unsatisfactory or Suspicious Findings on Palpation—Palpation of the main bile duct is a very unsatisfactory means of demonstration of disease in doubtful cases. An enlarged cystic duct

gland or enlarged gland in the region of the duodenum and the retroduodenal portion of the common duct is common and when palpated through other tissues is difficult to demonstrate as being outside of the duct. Small stones in the common bile duct are rarely palpable. Abnormal or dubious findings should indicate exploration of the common bile duct. This enables one to pass a probe through the ampulla of Vater and one can then palpate much more satisfactorily against the probe.

Small Stones in the Gallbladder with a Patent Cystic Duct—The second most frequent indication for exploration of the common duct is small stones in the gallbladder with a patent cystic duct which enables stones to pass readily into the main bile duct. Palpation of the gallbladder particularly when it is partially emptied by pressure to determine more satisfactorily whether stones are present may cause a small stone to pass directly into the common duct. On many occasions under these circumstances we have found one or more small stones in a common bile duct normal in appearance and to palpation. The surgeon may feel that such small stones in the common bile duct will readily pass into the duodenum but this is by no means assured. In this Clinic it is a routine procedure to have the gallbladder opened immediately; a careful inspection of the contents of the organ assists in determining the necessity for common duct exploration. Because of the danger of small stones passing from the gallbladder into the common duct during manipulation of the gallbladder the gallbladder should be removed prior to exploration of the common duct unless malignancy of the pancreas or main bile duct is suspected. If on the other hand the common duct is explored first the cystic duct should be closed off in some way. Even though the surgeon may assume that these small stones in an otherwise normal common duct might pass out of the duct it is his responsibility to be certain that the main bile ducts are clear at the conclusion of the operation. This is possible only by thorough exploration of the common bile duct at the conclusion of cholecystectomy.

Sediment in Aspirated Common Duct Bile—Dr. Lahey has called attention to an additional aid in ascertaining that the main bile ducts are free of disease. At the conclusion of cholecystectomy bile may be aspirated from the common bile duct with a hypodermic needle. If sediment, detritus or dark bile is

found common duct disease may be present. Under such circumstances this may have resulted from forcing gallbladder bile or sediment through the cystic duct into the common duct. The normal bile in the common duct is light yellow and lacks the concentrated dark color of gallbladder bile. Sediment or sand may be the only indication of common duct stone. Our figures of the incidence of common duct stone include only those cases in which definite calculi were present. Without question some patients have symptoms because of partial reflux into the lower end of the common duct with resultant infection or have concentration of bile in the duct with the formation of sediment, detritus or mud. In these cases the common duct should be explored and cleared and this is most effectively done by irrigation and lavage.

Acute or Subacute Pancreatitis or Hepatitis—Acute inflammation of the pancreas in the form of interstitial pancreatitis, hemorrhagic pancreatitis or pancreatitis with fat necrosis may be associated with common duct stone or inflammation of the main bile duct. In our experience there is no indication for a direct surgical attack on the pancreas itself. It is unwise to incise the pancreatic capsule to open the gastrohepatic omentum over the pancreas or even to drain the area of the pancreas. Cholecystostomy offers possible benefit in some cases and one should be sure a stone at the lower end of the common bile duct is not a primary or precipitating cause of the condition. Drainage of the common duct in our opinion is a more direct approach than drainage of the gallbladder. Sometimes acute or subacute pancreatitis is a serious complication of neglected gallbladder disease and it is one of the reasons for immediate operation for acute cholecystitis. In these long standing and neglected gallbladder cases the common duct is more apt to be involved. The rather indefinite and puzzling finding of chronic pancreatitis or thickening in the head and body of the pancreas probably has no relation to common duct disease. A few patients with chills and fever associated with common duct stone may have operative findings suggestive of acute pancreatitis. Exploration and prolonged drainage of the common duct may be of definite help in aiding this process to subside.

Acute Cholecystitis—In recent years we have performed cholecystectomy in most cases of acute cholecystitis. We at

tempt the same anatomic exposure of the ducts and usually can expose and explore the common duct. Rarely, only simple drainage of the gallbladder is indicated. A larger proportion of cases require only cholecystectomy, but in an appreciable number one of the above conditions will indicate the advisability of common duct exploration and drainage.

INCIDENCE

A consideration of the foregoing indications for exploration of the common bile duct shows why 48.8 per cent of the patients with gallbladder disease operated upon from 1938 to 1941 had exploration of the common duct. Our experiences in the exploration of 1,162 common ducts up to 1942 has convinced us that this is an important part of gallbladder surgery. In the years 1930 to 1941, 329 patients had common duct stones and 151 patients had malignancy of the biliary tract or pancreas. This group of nearly 500 patients with serious common duct disease makes us particularly aware of the possibility of some such finding in any gallbladder patient.

TECHNIC

We have not used cholangiography as a part of the operative procedure itself but have relied on exploration by probing, grasping instrument, scoop and irrigation. The technic of choledochostomy was presented in *The Surgical Clinics of North America* in June 1937 and a description of this procedure will not be repeated here. It should be stated that the common duct is explored through a separate incision in the common bile duct itself. The ampulla and papilla of Vater not only should be palpated but dilated moderately. In all common duct explorations, whether the findings are normal or abnormal, the common bile duct is drained with a T tube. This is clamped off for increasing periods beginning on the seventh postoperative day until by the twelfth day it is clamped off all day with drainage at night. As soon as the stools are well colored, the T tube is removed and bile drainage ceases within a few hours thereafter. In patients with marked dilatation of the biliary tract, drainage is continued for approximately three months. If a severe degree of cholangitis is present, drainage is continued for three to six months. If stricture formation in association with

common duct stone is found the T tube is left as a mold in the common duct for twelve months. Gentle irrigation by gravity utilizing normal saline solution may be helpful in keeping the tube free when it is left for longer periods of time. If the stools do not become colored at the time anticipated cholangiography by injection of the T tube with diatrast or lipiodol is carried out. Likewise in patients in whom prolonged drainage is utilized visualization of the biliary tract is a routine procedure.

SUMMARY

The incidence of common duct exploration in gallbladder cases has been presented. In the years 1938 to 1941 inclusive 909 patients with gallbladder disease were operated upon and 444 had their common ducts explored (48.8 per cent). One hundred and twenty eight (14.1 per cent) had their common ducts explored. There were 21 operative deaths (a mortality of 2.3 per cent) in the 909 patients.

The indications for common duct exploration in this Clinic have been listed and discussed. Exploration can be carried out with few complications, a low incidence of persistent common duct disease and a low mortality.

BENIGN STRICTURES OF THE BILE DUCTS CAUSES AND METHODS OF REPAIR

RICHARD B CATTELL

DURING 1942 19 patients were operated upon for benign strictures of the bile ducts this being the exact number operated upon in the four years previously. Unquestionably this large number of benign strictures during the last year represents a selected group of patients since all were referred to the Lahey Clinic because of unsatisfactory results following gall bladder surgery elsewhere. Benign strictures are not common and present such difficult reparative problems that I wish to present some of our experiences with them. The last discussion from the Clinic on this subject was presented by Dr. Lahey in 1937.

CAUSES AND PREVENTION

The causes of benign stricture of the bile ducts may be listed as follows

- 1 Ulceration from gallstones
- 2 Inflammation of main bile duct
- 3 Operative injuries
 - (a) Excision of duct portion
 - (b) Clamping during operative hemorrhage
- 4 Following subtotal gastrectomy

The prevention of benign strictures from these causes consists in the following measures

- 1 Early operation for gallstones
- 2 Early and prolonged drainage of the common duct
- 3 Adequate exposure of the duct and hepatic artery pressure and suction
- 4 Dissection of the common duct and T tube implantation

1 *Ulceration from Gallstones*—This is an infrequent cause of benign stricture yet we have encountered it a number of times

in patients without previous operation. Stones may become impacted at the junction of the cystic and main ducts and ulcerate, destroying the anterior wall of the common duct. They may ulcerate through the anterior portion of the common duct into the head of the pancreas. It is well recognized that stones may ulcerate and pass through any structure with which they come in contact (Fig. 161) and as these areas heal sufficient constriction to produce an actual stricture may result. This complication may be prevented by early removal of gallstones and

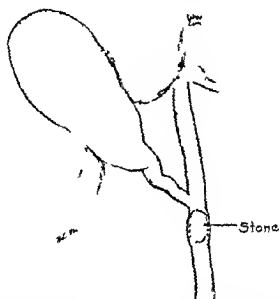


Fig. 161—A gallstone is impacted in the common duct. Injury to this system may result in the type of stricture shown in Fig. 166.

recommend cholecystectomy for any patient with gallstones in whom there is no definite contraindication.

2 Inflammation of Main Bile Duct—Cholangitis involving all the extrahepatic bile passages is fortunately infrequent unless associated with gallbladder disease. At the Lahey Clinic we have encountered narrowing and fibrosis of the entire main bile duct system that could be explained only on this basis (Fig. 162). In other cases this inflammation may involve limited portions of the intrahepatic ducts forming a small area of stricture which is discovered only by probing. Cholangitis tends to be recurrent.

and the end result may be a fibrous duct with a greatly diminished lumen. Inflammation of the main bile duct is most apt to occur in neglected gallbladder cases. Early operation for gall stones and early and prolonged drainage of the common duct if cholangitis is present should offer the best prevention of stricture from this cause.

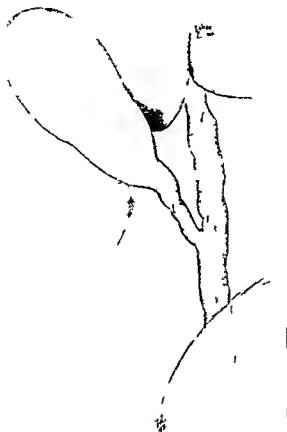


Fig. 162—Inflammation is present in all the extrahepatic ducts and in the instances involvement may be present in the intrahepatic ducts. Stricture may later be present in any or all portions of the ducts.

3 *Operative Injuries*—This is by far the most common cause of benign stricture approximately 80 per cent of our cases having this origin. Most of the cases fall into one of two types of injuries. The first is excision of a portion of the main bile duct. Traction on the gallbladder may angulate the common duct upward so that a clamp can be placed across the common duct (Fig. 163 1). This would be evident to the surgeon if the area of the cystic duct were examined after removal of the specimen.

and results of course in complete obstruction of the common duct unless a biliary fistula relieves it. Secondly, the common duct may be partially obstructed by placing the cystic duct clamp too closely on the wall of the common duct (Fig 163 *b*). This method of injury may seem unlikely yet in 16 of our patients the stricture was found at the site of the usual entrance of the cystic duct. In 2 patients in the last two years all the

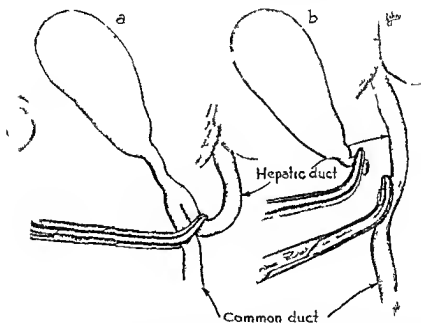


Fig 163—*a* A clamp is placed across both the common and minor hepatic duct with a portion of them removed through the gallbladder. *b* The stricture in the common duct may be obstructed by the cystic duct clamp.

extrabiliary ducts between the liver edge and the upper edge of the duodenum were missing.

A common history of stricture includes *hemorrhage* at the time of a previous gallbladder operation. This usually is the result of loss of the cystic artery (Fig 164). Since the cystic artery is shorter than the cystic duct, traction on the gallbladder to visualize the latter may tear off the cystic artery. In a patient with a great deal of fat in the gastrohepatic omentum, the clamp may pull off during the ligation. When the wound fills with blood, the surgeon attempts to secure the artery by placing a

clamp in the general direction of the bleeding area. The history of hemorrhage during cholecystectomy was given in 34 of our cases.

Since stricture as a result of operative injury is preventable it is a real tragedy. To avoid such difficulty adequate exposure for a gallbladder operation is essential. Some regular plan or technic should be adopted. Whether the surgeon chooses to remove the gallbladder from above downward or below upward makes little difference, but with either method he should be cer-

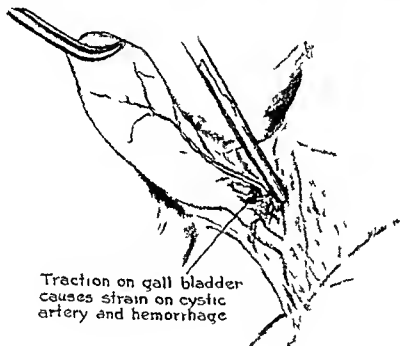


Fig. 164—The clamp is shown being plunged in the general area of the cystic artery in a bloody field resulting in a portion of the common hepatic duct being injured.

tain of the anatomy and familiar with the common anatomic variations and should not divide structures until the operative field is well visualized. It is our practice to secure the cystic artery first then to visualize the common hepatic duct, common duct and cystic duct before dividing the last under direct vision. The older plan of placing a clamp across the cystic duct and cystic artery and ligating them together should be abandoned. The cystic duct stump should be ligated a short distance from the wall of the common duct after making sure that no stone

is impacted at the junction. If hemorrhage from the hepatic artery occurs it can be controlled readily by pressure on the hepatic artery near its origin with the finger in the foramen of Winslow behind the gastrohepatic omentum and the thumb in front. After the field is cleared of blood the torn cystic artery can be dissected free and secured without danger.

4 *Following Subtotal Gastrectomy*—A stricture of the bile duct occasionally follows subtotal gastrectomy. With the in-

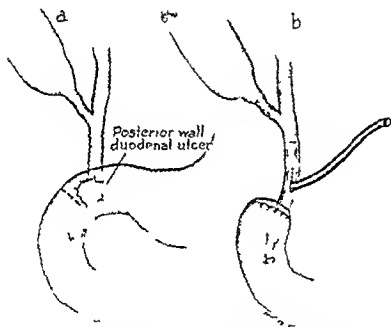


Fig. 165—*a* A posterior duodenal wall ulcer outlined in the region of the common duct. *b* This shows the duodenum closed with the ulcer resected without interference with the common duct. A T tube having been implanted.

creasing application of subtotal gastrectomy for intractable and complicated duodenal ulcer more and more ulcers on the posterior wall of the duodenum are encountered many of which come in close relation to the lower end of the common duct. The common duct may become so involved that removal of the ulcer is unwise. To effect safe closure of the duodenal stump it may be advisable to isolate the lower end of the common duct, open it and insert a tube in the lower end (Fig. 165).

The entry of the tube into the papilla can be seen with the duodenum opened giving the surgeon a security for the duodenal closure. If the T tube is left in the common duct with the lower end passing through the papilla until healing has occurred stricture can be avoided.

OPERATIVE PRINCIPLES

From our experience with over 80 patients with benign stricture, certain principles of technique have evolved. An analysis of failures and fatalities together with findings on reoperation, has provided valuable information for the treatment of future cases. The transplantation of external biliary fistula was used in a number of our early cases and was early reported by Drs. Lahey and Hugh Williams. However since other methods of repair have since proved more satisfactory this method has been largely abandoned.

The following principles of repair should be emphasized:

- 1 The mucosa should be approximated accurately to the mucosa. This may be the mucosa of the approximated duct portions or may be the mucosa of the duct to mucosa of the duodenum or jejunum.
- 2 Accurate approximation without tension is important. Usually only one row of sutures can be used for repair and this will give a good result if there is no opportunity to pull apart. The gastrohepatic omentum can be used to reduce tension and if the duodenum or jejunum is used it can be anchored to the sides of the anastomosis.
- 3 The T tube which we use for the repair of most of our strictures should be inserted through a separate incision in the duct. If the T tube is brought out along the line of repair its withdrawal may forcibly separate a portion of the anastomosis and result in recurrence. A separate incision in either the proximal or distal duct portion is usually possible bringing one of the limbs of the T tube through the anastomosis.
- 4 If an indwelling tube is used particularly if the lower end passes down into the duodenum through the ampulla or into the duodenum or jejunum through a separate incision it is quite important to anchor the tube by means of a nonabsorbable suture so that it will remain long enough to serve as a mold at the line of repair.

is impacted at the junction. If hemorrhage from the hepatic artery occurs it can be controlled readily by pressure on the hepatic artery near its origin with the finger in the foramen of Winslow behind the gastrohepatic omentum and the thumb in front. After the field is cleared of blood the torn cystic artery can be dissected free and secured without danger.

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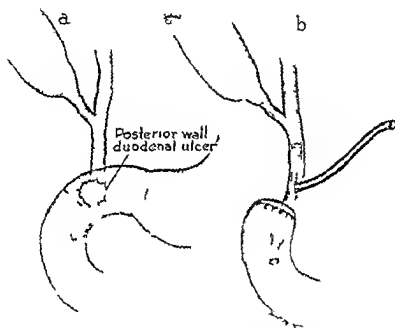


Fig. 165—*a* A posterior duodenal ulcer is outlined in the region of the common duct. *b* This shows the duodenum closed with the ulcer resected without interference with the common duct. A T tube having been implanted

creasing application of subtotal gastrectomy for intractable and complicated duodenal ulcer more and more ulcers on the posterior wall of the duodenum are encountered many of which come in close relation to the lower end of the common duct. The common duct may become so involved that removal of the ulcer is unwise. To effect safe closure of the duodenal stump it may be advisable to isolate the lower end of the common duct, open it and insert a tube in the lower end (Fig. 165)

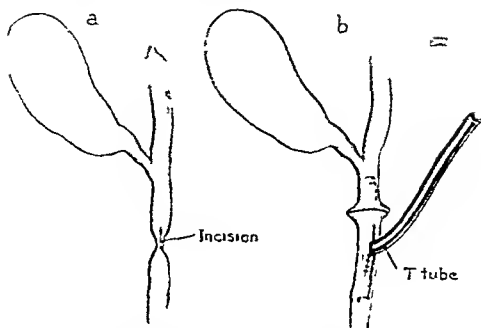


FIG 16—*a* Longitudinal incision through a stricture *b* With transverse suture and T tube implantation

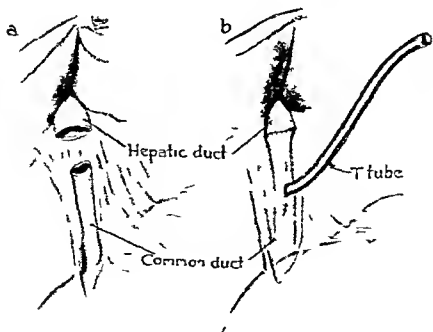


FIG 15—*a*. The area of stricture has been excised isolating and mobilizing the proximal distal ends of the duct. *b* The duct is then reconstructed over a T tube.

of the duct and passed upward past the line of repair (Fig 167). This method of repair is satisfactory and results in few failures if the principles of repair previously outlined are employed.

3 *Tube Implantation*—If long portions of the duct are missing or marked narrowing of a considerable portion of the stump

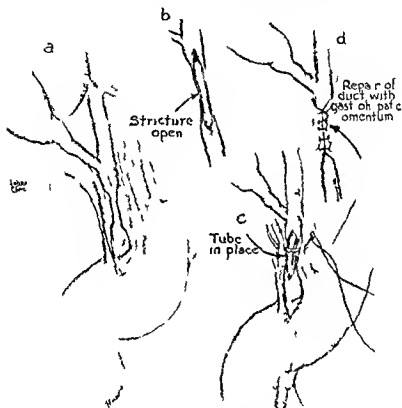


Fig 168—A large portion of the common duct is indurated by stricture.
b The stricture has been excised leaving a small cuff of mucosa posteriorly.
c The tube has been passed through the stump and into the proximal hepatic duct bridging the defect.
d The defect is closed by suture of the gastrohepatic omentum.

is present approximation of duct portions may be difficult. We have utilized tube implantations in some of these cases with some success (Fig 168). The tube bridges the defect and is anchored securely and repair is accomplished by means of covering the tube with gastrohepatic omentum. Unsatisfactory results will follow passage of the tube. In this situation a vitallium tube as

recommended by Pearse and Clute may find its greatest usefulness. In my opinion it is better in these cases to anastomose the proximal duct to either the duodenum or jejunum but we have used a vitallium tube in 1 patient.

4 *Hepaticojejunostomy*—If large portions of the duct are missing it may be impossible to bring the remaining portions together and may be difficult to bring the duodenum up to its

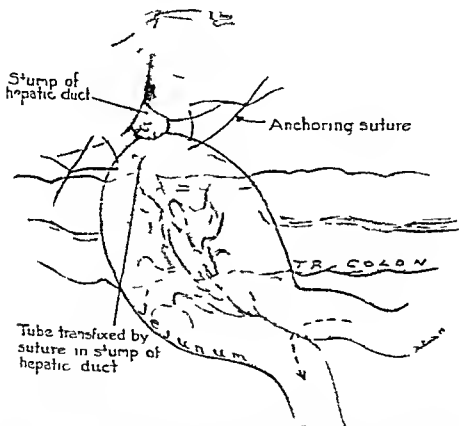


FIG 169—A stump of the hepatic duct has been isolated, and an anastomosis done to a long loop of jejunum over a short tube. The operation is completed by entero-enterostomy.

short hepatic duct stump. In our most recent cases we have utilized hepaticojejunostomy as the best site of intestinal anastomosis (Fig 169). An 18 or 20 inch loop of jejunum is brought over in an antecolic position and anastomosed to the dilated hepatic duct stump over a short tube carefully approximating the mucosa of the duct to the mucosa of the jejunum. An open form of anastomosis utilizing two layers seems

of the duct and passed upward past the line of repair (Fig 167). This method of repair is satisfactory and results in few failures if the principles of repair previously outlined are employed.

3 *Tube Implantation*—If long portions of the duct are missing or marked narrowing of a considerable portion of the stump

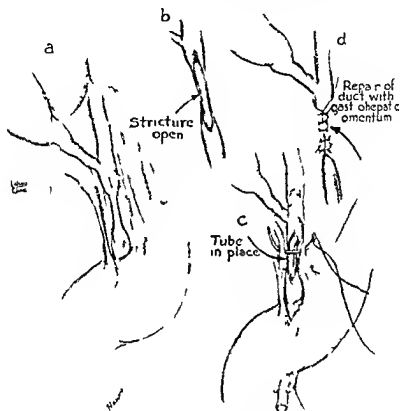


Fig 168—A large portion of the main duct is closed by stricture.
b The stricture has been excised leaving small strip of mucosa posteriorly.
 The tube has been passed through the ampulla and into the proximal hepatic duct bridging the defect. *d* The defect is closed by suture of the gallbladder. The repair of the duct is covered by gastrohepatic omentum.

is present approximation of duct portions may be difficult. We have utilized tube implantations in some of these cases with some success (Fig 168). The tube bridges the defect and is anchored securely and repair is accomplished by means of covering the tube with gastrohepatic omentum. Unsatisfactory results will follow passage of the tube. In this situation a vitallium tube as

denal approach. The occurrence of stricture and fibrosis in this area has not been well recognized and may be the cause of failure to relieve symptoms after cholecystectomy and choledochostomy. In these cases prolonged drainage is carried out, the T tube being left for at least twelve months.

SUMMARY

The causes of benign strictures of the bile ducts are discussed. Injury of the duct at operation occurred in 80 per cent of cases.

Earlier operation for gallstones and satisfactory operative exposure of the gallbladder and ducts during cholecystectomy are the best means of preventing benign strictures.

The surgical principles which are necessary to obtain satisfactory repair are outlined.

Plastic repair, dilatation and tube implantation, end to end suture and hepaticojejunostomy give the best results. Transplantation of an external biliary fistula and tube implantation leaving a defect in the duct should be avoided if possible.

FINDING THE LOWER END OF THE CUT COMMON DUCT IN STRICTURES OF THE COMMON DUCT

FRANK H. LAHEY

ANOTHER article in this symposium discusses strictures of the common or hepatic duct and also the more difficult problem involved when an entire section of the common or hepatic duct is accidentally removed. A number of such patients have been and are being sent to the Clinic for reparative surgery on the bile ducts and one of the most difficult parts of the undertaking because of the amount of scarring present is finding the lower end of the common duct.

If one can find the lower end of the cut or strictured hepatic and common duct the upper end frequently demonstrates itself since it often balloons out like a base drum from bile pressure particularly if the biliary fistula has closed itself. If the biliary fistula has not closed itself it can often be followed up through the fistulous opening into the upper end of the duct into which a tube of vitallium or rubber can be inserted and the other end permanently inserted into the demonstrated lower end and the duct reconstructed about it by bringing the scarred tissue over the tube where the duct is missing.

The difficulties of finding the lower end of the common duct are related not only to the scar but also to the fact that in searching for it one can open or tear into the portal vein which results in alarming and dangerous hemorrhage and unless promptly controlled by suture a fatality. In dealing with common or hepatic duct stricture I have opened the portal vein in 7 patients but have always been able to sew it up with black silk lock or interrupted stitches and there has been no fatality in any of these cases. It is however an alarming situation and one which everyone wishes to avoid.

A helpful method which I have employed not only in finding the common duct in stricture but in demonstrating the common duct in duodenal ulcer adherent to the common duct is mobiliz

ing the duodenum by ligating the small vessels which run in at right angles to its extraperitoneal edge and severing the peritoneal covering of the duodenum as it spreads over the posterior wall rotating the duodenum inward and demonstrating the uninvolved common duct behind the duodenum where it is free from scar. In many instances it will be necessary to

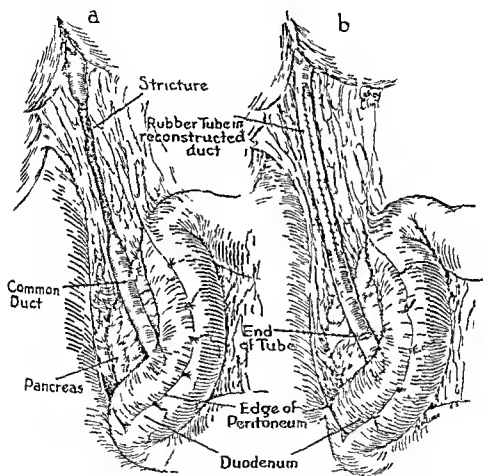


Fig 171—The duodenum has been turned over the duct behind it demonstrated and the tube is shown implanted in both ends of the cut duct but not projecting into the duodenum through the sphincter

dissect the duct from out of the head of the pancreas and in others the duct can be readily demonstrated as free behind the duodenum (Fig 171). If all other methods fail the duodenum can be opened the papilla found and a probe passed up into it to demonstrate the duct. This is not as easy as one might think since the papilla is not easy to demonstrate in the folds of duo

denal mucosa and is always located lower in the duodenum than one suspects

Particularly in the stricture cases this plan of turning the duodenum over has proved a time saving method of finding the lower end of the duct. One should also remember that if a tube is to be permanently inserted into this duct one should use a tube of larger caliber than the duct sphincter so that it will not pass through the sphincter into the duodenum and be passed out of the duct into the duodenum to result in a stricture and the recurrence of jaundice

SPONTANEOUS INTERNAL BILIARY FISTULA

MARTIN L TRACEY and DAVID McC McKELL Jr

SPONTANEOUS internal biliary fistula as the cause of upper abdominal symptoms is rarely considered preoperatively and is demonstrated only infrequently prior to operation. Between



Fig 172



Fig 173

Fig 172—Roentgenogram showing fistula and filling of biliary tree after barium meal (Case 18)

Fig 173—Roentgenogram three hours after barium meal barium still in biliary tree (Case 18)

1937 and 1942 21 cases were found at the Lahey Clinic during operation.

Five fistulas (Cases 9, 11, 16, 18 and 21) were demonstrated by roentgenologic study, 3 (Cases 9, 11 and 16) of which were proved at operation. One patient (Case 18) aged 74 years refused hospitalization for further study (Figs 172 and 173). One other patient (Case 21) operated upon elsewhere without demonstration of a fistula showed filling of the biliary tree during

two roentgenologic examinations (Fig 174) but it was not certain whether this filling was through a patent ampulla of Vater or a fistulous connection between the duodenum and the common duct. The gallbladder was not studied but was reported normal at operation elsewhere. Air outlining the biliary tree is almost unfailingly pathognomonic of biliary fistula (Fig 175).

In addition 7 (Cases 8 and 19) of 10 patients studied with a barium meal showed some change in the average normal pattern in the descending duodenum and 1 patient (Case 22) showed barium retention in the right upper quadrant during a barium



Fig 14—R. nitrogen gas showing filling of biliary tree after barium meal (Case 21). Arrow points to questionable fistula.

enema examination twenty-four hours after the barium meal. These findings were probably due to fistulas but the diagnoses were not made preoperatively.

In 6 patients (including Case 1 in which the connections of the fistula were not demonstrated) the gallbladder had been removed previously. Eleven gallbladders were studied with the Graham test 9 of which did not visualize. Six of these were studied by the oral method and 5 by the intravenous method including 1 by both methods (Case 15) and 1 by two intravenous tests (Case 16).

One patient (not included in this series) was operated upon for gallstone ileus and the surgeon's operative note failed to mention a biliary fistula. It is possible that the stone passed through the ampulla³ or that the fistulous tract healed without detectable traces.³ Internal biliary fistulas undoubtedly occur more often than they are discovered and heal spontaneously without detectable traces.

The *symptoms* are similar to those usually associated with biliary disease. However the colic is severe and the symptoms



Fig 175

Fig 175—Roentgenogram showing air outlining biliary tract



Fig 176

Fig 176—Roentgenogram showing fistula from hepatic flexure to common duct (Case 16)

are more distressing than in uncomplicated biliary calculi. Many patients are said to have periods of complete freedom from symptoms after a particularly severe attack of colic.³ This symptom free period is perhaps the one thing that should make the physician think of an internal biliary fistula although it was mentioned only three times (Cases 4, 16 and 22) in our series and Puestow⁴ disavows this belief. Perhaps patients neglect to relate old attacks in their concern over present difficulties. When there is a fistulous connection with flow into the biliary tree one can theorize about the possible harmful effects of gas

TABULATION
SUMMARY OF 23 CASE OF SPONTANEOUS INTERN L. BILIA Y FISTULA

N	Age	D Fts	Sex	Phys. al E. m. t.	Rec. to E. m. m.	One	diag.	Oper. t.	Com.
1	46 F	7/1/2	Chl. y 7/5/26	N. g.	Stom. b. m. all. es d. c.			Plast. para mm. d. wh. b. was d. 7/ 13/7	Will. f. 18 m. h. Chills d. f. d. pon lly l. d. cy
		12/17/28	Chill. d. f.						Chill. d. f. b.
		2/23/29	T. d. m. a. s. p. gast. m.	M. s. m. l. b. e. c. u. t. m. a. c. h.		f. t. r. l. b. l. ry. f. a. f. l. m. d.		P. od. tin. f. b. l. y. h. e. l. 3/23/29	F. ly. w. h.
		7/26/31	J. d. h. l. d.					W. nag. f. b. b. h. p. t. 3/23/31	Chills f. d. d. p. e. m. t. f. d. l. p. e. t. ald. od. al. fast. l. bo. t. Oct. 1932 E. f. r. t. l. eed. bey. d. f. a. u. l. w. h. b. e. es. f. u. l. R. t. m. d. hosp. t. t.
		9/7/33	E. m. l. b. l. f. a. q. dr. t. D. od. m. f.			C. l. es. v. y. t. pos. t. m. m.		P. rial. ga. rect. my. m. p. r. e. s. from d. od. al. b. a. 11/12/33	D. d. N. 22 1933 f. m. h. m. h. g. through w. d. d. gas. r. y. on. l. t. r. a. c. t. P. l. h. o. l. f. d. l. f. u. t. l. a. Ch. f. d. o. c. h. o. d. od. al. f. l. E. r. o. s. f. d. od. m. p.
2	7 M	7/29	Col. m. o. n. b. d. f.		G. l. i. e. t. m. i. d. t. f. i. m. f. b. d. m. C. m. a. t.	S. m. e.	U. b. l. a. d. d.	Ch. l. d. h. t. m. y. d. d. m. y. 1/1/33	C. r. i. b. o. s. f. l. i. t. o. e. s. N. f. b. m. a. s. b. i. t. a. l. m. e. m. y. f. l. e. e. r.

3	4	6/24/38	C1 2y rs	L ₁ d h t m g	Ch t t h h t m t t	S	g hbl dd	Ch t cy tee my f	Q t bl	D d
4	63 M	8/24/32	C1 m y y N y mpt m S i y m th	N g t	I t d dy hbl d t Q est bl B m m g t	St d	g hbl dd d mm d t	Ch t d h t my h t y t t my t t 9/3/32	V y good b hth 14 m th l t	9/11/38 Quen d b
5	61 F	4/21/33	C1 f d f d hll 1 y	L f h t b l ost l m g	I t d dy g hbl d t g g hbl d l th t	St d t	mm	N g hbl dd f d p bly d t y d d c t t d y M f t l l	Ch t doch t my f 14/35 f wh dit t h g t l k s 4/8/39	
6	56 F	8/8/34	C1 6 m th	T d ppe q d t t bd m	N m l g t t f t l t O l g hbl d l dy fll g f g hbl dd	St d t	mm	Ch l d h t my h l y t t my t l 8/27/34	W h t l 1937 flos p t l u d l w b so k w	
7	69 F	10/30/34	J d f bll 2 y	N g t	O t g hbl dd d y t g g hbl dd	St d t	g hbl dd d mm	Ch l d h t my b l y t t my t l 11/1/34	D d f u tee th post perat d y l m y mbol	
8	58 F	1/21/37	J und c hlls d f r 2 y rs	L f h t l t Sp t f s b dth be i ost i m g n	P r t lll g f m p u t t t t b m m t	St d t	mm d b th h p t d t s	Ch l d h t my h l y t t my t l 2/9/37	D d g hth post p- t d y B ho- p m t l tho- g p o t b c h lccyatt b l l th f t l d od f l t l cutbox m s ly	
9	22 M	10/6/37	C1 l d f dchll 8 y rs	T d ppe q d t t bd m	St d l wh re g y t p ly l t d dy c fl t g t b l ry	St d t	mm d both h p t d t	Ch l d h t my b l y t t my t l 10/18/37	St dy mp m t D Ap 1939 f hock	
10	50 F	11/10/37	C1 d j u d 5 y rs	L b d	L f h t t l	St d t	g hbl dd d mm d t	Ch l d h t my b l y t t my t l 11/16/37	W h 5/6/38 ry w y	

TABULATION—Cott d

C ₂ N	Ag Se	D F rel Se	P t H t y	Phys E. m	Ree t L. m	Op t F d m	Ope	C r s
11	57 F	12 3 7	Ch l y F b 1 36 C l d j und O y	T d e p p b d m	Ch l y d d t f e f b m m l d d od l l 12/6/37		Ch l d b h f d e t o e t my p baby p e l g d od ad l 12 R 37	Good rec h t b 6/6/3
12	39 N	6/6/38	Ch 6 m ha	N t	O t eall b d d f t o m g f b d d	S es z ill d d	Ch l d b h l s d 6 9 38	U f l
13	60 P	6/29/38	C l 9 m h	F od) d m quad m	l e d d A b d m l T d e b t p r f b d	S g all d d	Ch l y t d pos t m o e 7/15/38	ympt ms O c 1941
		10/17/41	C 2 w ka				Ch l y 10/24/41	
		3/9/42	B resp al f bur tis				Ch l y t t my d los re t f s t l 4/1/42	bd m t ymp m C d b d l d b 10/ 9/42
14	50 F	5/26/39	Ch l y t f any 1936 Adhes na ev d 4 p 1939 l t m t d 25 y ars	T d m e p p e quad b m	ht f		Ch l d b t my d pl f f f d t 6/5/39	S my R dm d t h p l
		8 2 /3	J d	l m s ly d es	Obs l m b f T p p e l od l d o o d d m h h f w f m b		R f d	S l w ly p m t w b o a l d 6/19

15	41 F	6/1/40	Ch 1 1933 Y 1 7 y ars C 1 1 m y	Obe	O 1 g 111 d d d b d d d d d t m g t 111 d d d d d d d d	Ch 1 1933 Y 1 7 y ars C 1 1 m y	6/18/41 ry w 11
16	40 F	3/27/41	C 1 5 y f m 1 f d m Lo bow 1 m	Ob	St m h g t O 1 g 111 d d d d d d d d 41 d 3/4/42 11 d f t l f m h p t 11 vu to h l ry t (m m d t)	Ch 1 d h t m y h l y t t m y t l 11/3/42	O m th l t d t d m l t t l p y M l d h g t t d by psy h t t
17	38 F	3/29/41	R pt d g 111 d d m d J 1938 C m m d t pl d J 1940 d A g 1940 C l d J d 3 y	N g t	St es h p 1 d t m m d f t l t t	Ch 1 d ch t m y t mos f f t m b p t d d t J l m t m y 3/5/41	P feet h lth 5/18/42
18	74 F	4/2/41	Ch lecy t t m y d h l e y t t m y 1912 C l 1925 Dy phag 3 m	I l h ght pp q d t	C m m d t d b l ry t m m l d b m t l d d t l B m m g t	R f d	D d 3/17/42 C se k
19	56 F	6/4/41	S t mach 8 m th M y y p t ry ul g t g l d po top t ly)	W ght 1 L f l t 4 m b l w t l b d	D 3 l p d f t Pock t d 6/5/41 1 m g 111 d d r d y h d d 6/7/41 t d g 111 d l d d y g 111 d t 9/14/41 O l true t d od l l 9/15/41	Ch 1 d h t m y h l y t t m y pe f t f d od d post t g t t t m y 12/ 19/41	Good h lth R t g post g t p f t m y t t ry 2/20/42 f l g m h b t 5/12/ 42

TABULATION-C 1 d d

C se N	Ag Se	D T t See	Pass H t y	Phy E m	Roe F m t	Op t F d	Op t	C rs
20	52 F	6/25/41	Ch l y 1939 Pl my m d d 1940 C l d j d 7 y	T d es f bt pce d t			Ch l d h f fus ul h l d b j b- est my p rt mm d t 8/8/41	W l f l m b
21	27 M	1/10/42	J d l m th	N c	h h ry be l d h m i G		Pl mm d bo- l d och j j est my d j j l o a my 2/28/42	Good beal h. N al b l ry ree f t film f ht pp q d 1 4/9/42
22	60 F	12/26/41	B ry d d l poly T ry cool o r y	N	S m b d d o- d l film l d bl g t mm d t	Op l p b b l d d d d m	Ch l d h t my b l y t t my t f 1/8/42	W l t f t t m g pos b l y f f b m hag 12/10/42
23	61 M	9/23/43	S l 23 y p ry udg f re c r v l 20 y rs m ho	Obe	O l alld d d dy q l d m d 24 b ex l l ar m t bt ppe q d	S d	Ch l d h t my b l y t t my t f 1/8/42	l good h l b 9/14/42
			Ch l y m F b 1 42 C l d l b l l l	N g t		S d t	E 9/25/42 f fus ul	U f l

tro-intestinal juices on the liver. Experiments in dogs¹ demonstrate progressive liver damage. Jaundice was present in 11 patients, fever in 7 and chills in 6 suggesting cholangitis. In Case 18 (fistula on roentgenologic examination but operation refused) a primary anemia with dysphagia and liver failure may have followed a fistula existing for many years. A cause and effect relation could not be established since the patient did not complete his examination. In Case 16 a fistula between the common duct and colon may have provoked diarrhea³ (Fig. 176).

Formation of a spontaneous internal biliary fistula is in no sense a cure of cholelithiasis but is an additional and dangerous complication. When this statement was made by Judd and Burden³ in 1925 surgery on the biliary tract particularly for the jaundiced patient was more formidable than it is now. The complication of biliary fistula should be less frequent in the future if early surgery for biliary colic is advocated.

OPERATIVE FINDINGS

On Graham test only 4 patients (Cases 2, 3, 5 and 9) showed stones although in 2 patients (Cases 4 and 22) there was a question of stones. However at operation stones were found in 13 patients and at postmortem examination stones were found in 1 patient (Case 1) in a pancreatic cavity. In the 8 cases with fistula in which stones were not found one can suspect that they had been passed without the patient's knowledge. Passage by rectum of gallstones is not noted in the histories of any of the patients with fistula.

Dense adhesions around a small contracted gallbladder commonly are found. In the separation of such adhesions a search should be made for a fistula since overlooking such a lesion may lead to peritonitis³.

The common duct was explored in 17 patients. Stones were found in the common duct in 9, in the hepatic ducts in 3 (Cases 8, 9 and 17) and in the fistula also in Case 17.

Two fistulas (Cases 11 and 19) were probably due to duodenal ulcer perforating into the gallbladder. No history suggesting gallbladder disease especially colic could be elicited in Case 19. Case 11 had stones and a perforating duodenal ulcer.

The *anatomic location* of the fistulas proved at operation follows:

Gallbladder to duodenum	12
Cystic duct to duodenum	2
Common duct to duodenum	4
Right hepatic duct to duodenum	1
Connection not mentioned	1
Common duct to proximal transverse colon	1
Total	21

RESULTS

Of the 21 patients with internal biliary fistula 2 patients (Cases 7 and 8) died in the hospital 1 of pulmonary embolism and the other of bronchopneumonia. One patient (Case 1) had had four operations over a period of six years and developed a duodenal fistula. Following partial gastrectomy to aid closure of this complication the patient died of hemorrhage (questionable hypoprothrombinemia before knowledge of vitamin K). One patient (Case 3) died a liver death following operation for intestinal obstruction (before discovery of vitamin K). One patient (Case 9) died of unrelated causes eighteen months post-operatively. Two patients (Cases 12 and 23) were not heard from after an uneventful hospital stay. The other 14 patients were well one month to four years after operation.

CONCLUSIONS

Operation for internal biliary fistula is successful. An external biliary fistula is more likely to occur with damage to the common duct such as severance, ligation or stricture. Such a complication was found only once (Case 1) although many patients with stricture are thought to have a spontaneous internal biliary fistula which allows for periods of improvement.

Severe colic for long periods especially with a long interval of freedom after a very severe attack should make the physician suspect a fistula. Barium studies of the gastrointestinal tract though not essential might reveal more fistulas if performed in the absence of visualization of the gallbladder. Whether a fistula is demonstrated preoperatively is not of great importance although delay in operation may increase the hazard and lead to liver damage. The operative procedure should include closure of the fistula or excision, cholecystectomy and exploration of the common duct. The complication of fistula probably will not be frequent if patients with biliary colic or demonstrated cholelithiasis are urged to have surgical treatment early.

SUMMARY

Twenty one cases of internal biliary fistula are reported. The preoperative diagnosis was made in 3 patients and proved at operation. Two other patients who might have fistulas are mentioned, both confirmed by roentgenologic examination. The importance of making the diagnosis preoperatively seems slight.

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POSTOPERATIVE PERIHEPATIC AND INTRAHEPATIC INFECTIONS LOCALIZATION AND MANAGEMENT

HERBERT D. ADAMS

INFECTION in or about the liver is a fairly common postoperative complication following many types of abdominal surgery. The exact localization and effective management of such infection may be difficult to accomplish and therefore some of the problems involved are worthy of discussion.

Following almost any type of abdominal surgery, especially biliary or gastro intestinal surgery including appendicitis such a complication as this type of infection may arise. Signs of an obscure infection may develop early or late in the postoperative period. When the more common sources such as the field of operation, the wound, the urinary tract and respiratory tract have been eliminated as a source of this reaction, attention should be focused on the right upper quadrant of the abdomen because of the possibility of perihepatic or intrahepatic infection.

Of course one should realize that there are many types and degrees of infection in the hepatic area. Such infection as a mild diffuse hepatitis or cholangitis or perihepatitis in the form of acute cellulitis may develop and subside under conservative measures and leave no residual abscess requiring surgical drainage. This type of infection while potentially serious may be only transitory and therefore of relatively little importance. However, a definite abscess or more frequently multiple abscesses within the substance of the liver or in relation to any of its surfaces definitely menace the patient's life unless effectively localized and drained. Unfortunately, as will be shown, many intrahepatic infections will prove fatal in spite of all efforts to control them and therefore the only effective treatment is prevention.

The perihepatic infections on the other hand are a much more favorable group and if effectively localized and drained

the mortality should be low. Exact localization of the abscess which may often be difficult therefore becomes the crucial factor in all these infections. Physical signs and roentgenologic findings are often confusing and as illustrated in the following cases lead to difficulty in effective drainage of these collections of pus.

SUBDIAPHRAGMATIC ABSCESS

The typical subdiaphragmatic abscess may be managed readily and satisfactorily. When signs of obscure infection develop after abdominal surgery a subdiaphragmatic abscess should be ruled out. There may be no symptoms referable to this area or at best only a vague discomfort in the low thoracic and subcostal areas. Deep tenderness may be demonstrable on pressure over the lower ribs and the diaphragm should be elevated and fixed on percussion. Roentgenologic examination especially with the patient in the upright and lateral positions is of great value and shows a definite shifting collection of gas beneath the diaphragm. As many of these infections are of a colon bacillus type gas develops within the abscess and produces this characteristic picture. The roentgenologic findings however may be very misleading. The following is a typical case of subdiaphragmatic abscess.

CASE I.—A 61 year old woman with epigastric discomfort of a year's duration and frequent vomiting of six months duration was admitted to the hospital with a diagnosis of carcinoma of the stomach. A subtotal gastrectomy was done. Because of her anemia and poor nutritional state two transfusions were given in the first few days following operation. On the twelfth postoperative day she began to develop edema of the legs which was thought to be due to low serum protein and secondary anemia. More transfusions were given in an effort to improve this condition. On the thirty second day she began to run a septic fever and course. Roentgenologic examinations showed the diaphragm elevated with moderate atelectasis of the lungs, a small amount of fluid and a definite collection of gas beneath the diaphragm (Fig 177 *a* and *b*). On the thirty fifth day a one stage drainage of the subdiaphragmatic abscess was undertaken. This was accomplished by removing a portion of the eleventh rib in the posterior axillary line. The two pleural surfaces of the costophrenic angle were sutured together and an opening made through the diaphragm into the abscess cavity. Following this

her temperature rapidly dropped and she was discharged some weeks later in good condition

Comment—This case illustrates accurate localization and effective drainage by the direct thoracic route. Drainage may

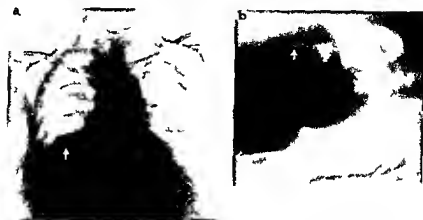


Fig 177—Sbd aphygram to be seen. Anteroposterior view with the patient upright showing a definite gas bubble below a high fixed right diaphragm. b Anteroposterior view with the patient lying on the left side showing the same bubble which has shifted with position.

be performed either in two stages or as in this case in a carefully executed one stage procedure

SUBHEPATIC INFECTION

The following 2 cases on the other hand illustrate how the clinical course and roentgenologic findings can readily prevent accurate localization cause unnecessary surgical exploration and delay effective drainage

CASE II—A 47 year old woman was admitted to the hospital because of abdominal pain of six months duration and jaundice of one month's duration. A cholecystectomy and exploration and drainage of the common duct were done. There was definite cholangitis, chronic cholecystitis and cholesterosis but no stones. Following operation she ran a low grade fever and on the seventh postoperative day showed fluid at the right base. On the eighteenth day roentgenologic examination showed the diaphragm to be elevated and fixed with small amounts of fluid in the costophrenic angle. There was no evidence of any free gas beneath the diaphragm. The

roentgenologic findings were suggestive of subdiaphragmatic abscess although the diagnosis could not be definite because of fluid obscuring the diaphragm. On the thirty second day roentgenologic examination showed pleural fluid above the diaphragm (Fig 178 *a* and *b*). A shifting bubble could not be located in relation to the diaphragm because although a thoracentesis had been performed several times prior to this examination the diaphragm could not be definitely outlined.

Since the evidence favored a subdiaphragmatic abscess and the patient continued to run a septic course a few days later a part of the eleventh rib was resected and the pleura packed as a first stage drainage. Aspirations and exploration of the subdiaphragmatic area

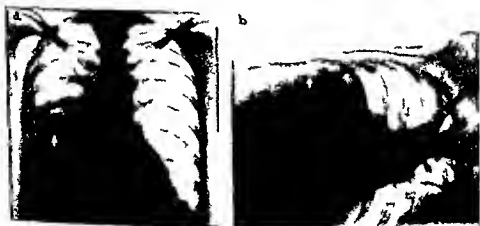


Fig 178—Subhepatic abscess *a* Anteroposterior view with the patient upright showing a small bubble in the region of the diaphragm. The exact position of the diaphragm is obscured. *b* Anteroposterior view with the patient lying on the left side showing the same bubble which shifted with position.

with a needle however produced no pus and therefore the final stage of drainage was not undertaken. She continued to run a septic course but a second exploration of the subdiaphragmatic area with a needle revealed no pus. At this stage the *subhepatic* area was explored through the wound and a large amount of pus was encountered. Following this she improved rapidly and was discharged in good condition.

CASE III—A 34 year old woman was admitted to the hospital complaining of attacks of right upper quadrant pain of some years duration. The diagnosis was cholecystitis and cholelithiasis and a cholecystectomy was performed. Convalescence was satisfactory until the drain was removed on the seventh postoperative day when

she developed pain in the right upper quadrant and lower chest. She began to run a septic course her temperature increasing to 103 F. in the afternoon. Roentgenologic examination showed the diaphragm to be elevated and cloudy at the level of the sixth rib and a small amount of fluid at the base (Fig. 179). On the fifteenth day a section of the eleventh rib was removed and the pleura packed. Two days later the second stage of drainage was carried out opening the diaphragm and exploring the subdiaphragmatic area; no exudate was found. She continued to run a septic course until finally a collection of pus in the subhepatic area was discovered and drained



Fig. 179—Subhepatic abscess. A. Elevated diaphragm with definite atelectasis above the diaphragm. Effusion and fluid at the right base.

through the wound. Following this she made steady improvement and was discharged in good condition.

Comment—These 2 cases illustrate that subhepatic infection may be accompanied by a clinical course and roentgenologic findings identical with those of subdiaphragmatic abscess even to the slight atelectasis and fluid above the diaphragm.

Case II even showed a shifting bubble of gas but the roentgenologist carefully stated that owing to fluid above the diaphragm obscuring its exact location it was impossible to say

definitely whether this gas was above or below the diaphragm. This patient had had several thoracenteses before this bubble appeared in the roentgenogram and the negative exploration of the subdiaphragmatic area and subsequent roentgenograms proved the bubble to be a small pneumothorax artificially induced at the time of thoracentesis. Careful consideration of the 3 cases brings out only one reliable differentiating point between subphrenic and subhepatic abscess and that is a shifting collection of gas shown by roentgenogram to be definitely below the diaphragm.

By carefully adhering to this criterion a negative exploration of the subphrenic region should rarely be made. However one exception is an intrahepatic abscess or most frequently multiple liver abscesses one of which lies beneath the capsule of the liver in the subdiaphragmatic position or has gone further to rupture through the capsule into one of the subdiaphragmatic spaces. These infections are usually not due to the gas forming type of bacteria and localizing positive evidence of this nature is unlikely. One often has to resort to localization by a long needle and aspirating syringe or exploration of the liver or the subdiaphragmatic area; however if the infection is deep within the substance of the liver even these more radical efforts may be unsuccessful.

INTRAHEPATIC INFECTION

The following cases illustrate the difficulties in localization and determination of the type of intrahepatic infection as well as its hopelessness and gravity.

CASE IV.—A 31 year old woman presented typical symptoms of appendicitis of three days duration and at operation the appendix was found to be perforated at the base and lying in the pelvis with peritonitis. An appendectomy with drainage was done. She made a fairly good immediate recovery but three weeks after operation began to run an intermittent fever. A tender mass developed in the posterior culdesac. Incision and drainage of this pelvic abscess were done by posterior colpotomy. She improved temporarily but later began to run a temperature of 102° to 104° F. daily. Her pulse rate was from 110 to 130. As the leukocytes numbered 15 000 and the erythrocytes showed progressive anemia she was given a transfusion. The first of a series of roentgenograms showed the chest to be clear and the diaphragm free. The final roentgenograms showed



Fig. 180—S. beapsul. l. er abs. c. the sul. d. apl. gn. t. c. p. st. High
 fi. ed. diaph. gm. ith. n. ch. r. t. e. s. t. n. l. e.



Fig. 181—Photograph of postm. rt. m. spec. m. of l. er. ho. multiple
 ab. c. es

the diaphragm to be high and the motion impaired. The liver shadow was increased (Fig 180) but there were absolutely no signs of fluid or reaction above the diaphragm.

Because the patient's condition became steadily more serious it was felt in spite of this inconclusive roentgenologic evidence that every effort should be made to discover her infection. A section of the eleventh rib was removed and the pleura packed. A few days later the diaphragm was opened and a large abscess cavity drained which was probably beneath the capsule of the liver adherent to the diaphragmatic peritoneum. Because of the continued septic fever and the lack of improvement it was thought that she probably had multiple liver abscesses. She continued to grow worse and died and a postmortem examination showed multiple liver abscesses and a pyelophlebitis of the portal vein. Figure 181 is a photograph of the liver.

CASE V—A 37 year old woman was operated upon for a ruptured appendix and peritonitis and subsequently continued to have



Fig 18 —Multiple liver abscesses high fixed diaphragm and characteristic reaction at the base of the right lung

intermittent abscesses in her wound and a draining sinus. About seven months later this sinus was explored and an appendiceal stump excised. The pathologic report was chronic inflammation of the

appendiceal stump. She was discharged about three weeks later in good condition. However, about ten days after leaving the hospital she developed vague pains in the right upper quadrant of the abdomen and in the costovertebral angle. Since this pain increased in severity and was accompanied by chills and fever, she was readmitted to the hospital. Chemotherapy and other conservative measures produced no results. After several weeks, exploration of the subhepatic and anterior aspects of the liver was carried out and a mass discovered in the anterior superior portion of the right lobe of the liver. The pathologic diagnosis of the biopsy specimen was nonspecific necrosis and chronic inflammation of the liver.

The patient's condition showed little change following operation. Some weeks later fluid appeared in the right base above the diaphragm and the diaphragm on this side became fixed and high (Fig 182). A thoracotomy and transpleural exploration of the subdiaphragmatic region were carried out but no exudate was encountered. Cultures of the pleural fluid and blood were negative. The high temperature curve continued and the patient slowly grew worse and died. Postmortem examination showed multiple liver abscesses and the bacteriologic studies showed actinomycosis.

CASE VI—A 62 year old woman entered the hospital with a history of acute attacks of right upper quadrant pain of five years duration. A diagnosis of cholecystitis, cholelithiasis and diaphragm



Fig 183—Subdiaphragmatic and intrahepatic infection. High fixed diaphragm with elevation above the diaphragm.

matic hernia was made. A cholecystectomy, choledochostomy and repair of the diaphragmatic hernia were performed. On the fourth postoperative day she developed a foul odor to the biliary drainage and slight necrosis along the drainage tract. On the ninth day evidence of collapse and shock developed. The blood pressure was 80 mm systolic and the pulse rate 150 and she showed extreme toxicity. Roentgenologic examination showed a high fixed diaphragm (Fig 183) suggesting a fulminating subdiaphragmatic infection. Gas bacillus infection was suspected and cultures were positive. The diagnosis was gas bacillus infection of the subhepatic area involving the entire liver. She received chemotherapy without effect and when positive cultures were obtained antitoxin was started. She rapidly became moribund and died.

Comment—These 3 patients had multiple abscesses and wide spread destruction of the liver substance and illustrate the serious nature of this condition. All 3 patients had all feasible surgical drainage and the last 2 had chemotherapy without influencing the steady progress of the disease and the ultimate fatal outcome. In this type of case surgical drainage at best can drain only the abscesses near the surface of the liver or those that have ruptured through the capsule and become subdiaphragmatic; this in no way influences the steady progress of the abscesses scattered throughout the liver substance. Although the bacteriology and the route of infection were dissimilar it is evident that in all three types of cases the complications of abdominal surgery directly responsible for the liver involvement must be prevented if the patient is to be saved.

DISCUSSION

In general it is important to realize that perihepatic abscess can be localized and effectively drained. A differential localization between subdiaphragmatic and subhepatic abscess may often be extremely difficult and since these patients can be saved it is far better to carry out unnecessary exploration than to let the infection go undrained. Likewise in intrahepatic infections the true nature of the disease is often obscured by the coexisting perihepatic infection. Since at this stage it is impossible to know of the intrahepatic extension of the infection drainage of the perihepatic and subcapsular abscesses is necessary until it is obvious that there are multiple intrahepatic abscesses and that the outlook is hopeless.

THE DIAGNOSIS OF CARCINOMA OF THE PANCREAS

EVERETT D KIEFER and MAX MORAVEC

The diagnosis of carcinoma of the pancreas has always been one of the more difficult problems of internal medicine. In the past the diagnosis was important only in establishing the prognosis and in ruling out curable conditions such as common duct stone. The cure of malignant disease of the pancreas was considered hopeless. Since advances in surgery have brought surgical cure of at least some cases of carcinoma of the pancreas within the range of possibility it is logical and timely to review the symptoms, signs, laboratory findings and clinical deductions which may lead to a reasonably accurate and early diagnosis. Elsewhere in this volume the present status of surgery in carcinoma of the pancreas is discussed by Dr Cattell.

Our review is based on a study of 74 cases of pancreatic carcinoma in all of which the diagnosis was confirmed by laparotomy. There were approximately twice as many men as women, 49 being men and 25 women. The distribution according to age was about the same as in carcinoma of the stomach.

Age	30-39	40-49	50-59	60-69	70-79
Number	3	13	32	19	7

Painless jaundice has been the traditional landmark of malignant disease of the pancreas or ampulla of Vater. Yet it is now well recognized that many patients with carcinoma of the pancreas (38 per cent) are not jaundiced when they present themselves for diagnosis. Since jaundice tends to localize the search for the morbid process to the region of the liver and bile ducts its presence makes possible a more direct attack upon the diagnostic problem. For this reason the patients with jaundice and those without jaundice will be considered separately.

NONJAUNDICED PATIENTS (28 CASES)

Patients without jaundice complained chiefly of pain. Although characteristic pain does not occur in every case certain

features should always suggest the possibility of pancreatic malignancy. These are (1) location in the epigastrium (2) prominent radiation to the middle of the back (3) steady progression in severity (4) aggravation by lying down and partial relief from sitting up or curving the body forward and (5) nonrelationship to meals or bowel movements.

The next most outstanding symptom is marked *anorexia*. A resulting loss of weight is almost constant and in most instances amounts to from 20 to 50 pounds. Given then a patient aged 50 years or over with characteristic pain, *anorexia* and weight loss the diagnosis of upper abdominal malignancy definitely can be suspected.

Such symptoms as *indigestion*, *nausea*, *vomiting*, *diarrhea* and *constipation* are frequently present but are much less characteristic and are not indicative of any one disease. Gross *hemorrhage* from the gastro intestinal tract may occur. *Fever* occurs surprisingly often. Unexplained chronic elevation of temperature with *anorexia* and gastro intestinal symptoms which remain undiagnosed after gastro intestinal study is strongly suggestive of pancreatic malignancy.

The *physical findings* are frequently insignificant except for weight loss. A palpable fixed mass in the mid or left epigastrium particularly if it transmits the pulsations of the abdominal aorta is evidence of a retroperitoneal tumor in the region of the pancreas. It should be remembered however that not all gastric neoplasms are movable and not all pancreatic tumors are completely fixed. Because of the retroperitoneal position of the pancreas it is relatively inaccessible to palpation and in 55 cases of the 74 no definite pancreatic mass was felt.

Laboratory findings provide only suggestive evidence of pancreatic disease or are useful only in eliminating other diagnoses. Contrary to what might be expected fatty stools are rare. Occult blood may be present in the stools apparently reaching the gastro intestinal tract by ulceration into the stomach, duodenum or pancreatic duct. Disturbed carbohydrate metabolism suggests pancreatic involvement but unfortunately gross disturbances are present in only a few cases. In 8 of the 74 cases glycosuria and hyperglycemia were found by routine urinalysis and blood sugar determinations. Berk¹ has reported that the glucose tolerance test gave evidence of some impairment of carbohydrate

utilization in 77.8 per cent of cases. Tests for pancreatic enzymes in the blood were not done on any appreciable number of our cases. Johnson and Boelus³ found the serum lipase elevated in 4 of 11 cases. Comfort and Osterberg have reported 40 per cent accuracy for serum lipase tests and only 8 per cent accuracy for serum amylase tests.

The roentgenologic findings may be entirely negative but frequently deformities and displacements of the stomach duo-



Fig 184



Fig 185

Fig 184—A filling defect on the greater curvature of the antrum of the stomach produced by a growth in the pyloric region just behind and below the stomach.

Fig 185—The characteristic 'C' shape of the duodenum caused by enlargement of the head of the pancreas around which the duodenum passes.

denum or colon indicate the presence of a tumor in the region of the pancreas.

Figure 184 shows the deformity and fixation of the antrum of the stomach produced by a carcinoma of the body of the pancreas. This sign is not always conclusive because an infiltrating gastric neoplasm on the posterior wall may have a similar appearance and gastroscopy may be helpful in making the differentiation.

Figure 185 shows enlargement of the head of the pancreas producing a widened sweep of the duodenum which normally curves around the pancreatic head. In interpreting this sign one

should remember that the width of the duodenal sweep varies and is usually wider in hyperasthenic patients with high transverse stomachs

Figure 186 shows displacement of the second portion of the duodenum

Figures 187 and 188 show pressure deformity of the third portion of the duodenum. Note the widening of the mucosal folds and the thinning of the barium column



Fig 186



Fig 187

Fig 186—Pressure on the duodenum by a pancreatic tumor is shown. The smooth rounded deformity and the slight displacement of the duodenum are suggestive evidence

Fig 187—The mucosal pattern of the duodenum is deformed and flattened by pressure on the second portion of the duodenum by a pancreatic carcinoma

Figure 189 shows the local distortion of the duodenal mucosal pattern in the region of the ampulla caused by a small tumor of the head of the pancreas

Summary—In nonjaundiced patients no symptom, sign, laboratory test or roentgenologic finding is pathognomonic of carcinoma of the pancreas. The best that the diagnostician can do is to make a probable diagnosis. With such ominous symptoms as persistent upper abdominal pain and weight loss in a patient over 50 years of age, particularly if gastro-intestinal roentgenograms show no intrinsic lesion, the diagnosis of carcinoma of the

utilization in 77.8 per cent of cases. Tests for pancreatic enzymes in the blood were not done on any appreciable number of our cases. Johnson and Boelus³ found the serum lipase elevated in 4 of 11 cases. Comfort and Osterberg have reported 40 per cent accuracy for serum lipase tests and only 8 per cent accuracy for serum amylase tests.

The *roentgenologic findings* may be entirely negative but frequently deformities and displacements of the stomach duo-



Fig. 184



Fig. 185

Fig. 184—A filling defect on the greater curvature of the antrum of the stomach as produced by growth in the pancreas which lies just behind and below the antrum.

Fig. 185—The characteristic 'C' shape of the duodenum as caused by enlargement of the head of the pancreas around which the duodenum passes.

denum or colon indicate the presence of a tumor in the region of the pancreas.

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Figure 185 shows enlargement of the head of the pancreas producing a widened sweep of the duodenum which normally curves around the pancreatic head. In interpreting this sign one

in pancreatic malignancy is due to the blocking of the common bile duct the first step is to identify the jaundice as obstructive

Tests for the presence of bile in the intestinal tract are significant. Probably the best test is simple inspection of the stool for a brown color indicating bile. Chemical tests for occult quantities of bile in the stool are merely confirmatory if negative and if positive do not rule out obstructive jaundice, since traces of bile may enter the intestinal tract even when the jaundice is due to pancreatic malignancy. Specimens of duodenal contents obtained by intubation sometimes contain small quantities of bile indicating that the obstruction is not always complete. As a rule the duodenal contents are bile free.

Urobilinogen is usually absent from the urine in obstructive jaundice since its presence depends upon bile entering the intestinal tract. In obstructive jaundice the plasma cholesterol may be moderately increased while in nonobstructive jaundice it may be lower than normal.

Tests for hepatic damage and decreased function, such as the bromsulfalein test, hippuric acid excretion test, galactose tolerance test and Takata Ara test give information regarding the condition of the liver. If liver function is impaired early in the course of jaundice a hepatic or nonobstructive form of jaundice may be suspected, particularly if considerable bile pigment is present in the stools. If obstructive jaundice has been present for several weeks impaired liver function may be found and indicates secondary biliary cirrhosis due to obstruction and back pressure in the biliary system. On physical examination the liver may be large and firm, usually with a rounded edge. Therefore hepatic damage may be considered as evidence either for or against biliary obstruction, depending upon the stage of the disease or other clinical findings of primary or secondary liver impairment.

After the jaundice is established as obstructive several forms of common duct obstruction must be ruled out before a diagnosis of carcinoma of the head of the pancreas can be made.

In the presence of obstructive jaundice a distended palpable gallbladder is highly significant and indicative of malignant disease. The clinical significance of this physical sign is known as *Courvoisier's law*. The absence of a dilated gallbladder associated with common duct obstruction due to gallstones is probably due

to the fact that in such cases chronic cholecystitis has so thickened the gallbladder that it fails to distend readily. When gallstones are coincidental with carcinoma of the pancreas the gallbladder is usually not dilated. Although a dilated gallbladder is not a constant finding it is one of the most reliable signs. In the presence of obstructive jaundice a dilated gallbladder and a pancreatic mass or roentgenologic evidence of a pancreatic tumor a diagnosis of carcinoma of the pancreas is fairly certain. However there is no way of differentiating carcinoma of the pancreas from carcinoma of the ampulla of Vater or of the common bile duct.

Other conditions which are practically impossible to differentiate from pancreatic malignancy without exploratory laparotomy are painless common duct stone, some forms of chronic pancreatitis, benign tumors and adenomas and retroperitoneal tumors such as lymphomas. Even with the tests which help in the diagnosis of liver disease and jaundice the differential diagnosis of obstructive and hepatic jaundice is not wholly reliable, particularly in cases of several weeks' duration in which secondary liver damage has occurred and obscures the primary biliary tract disease.

Because of the possibility of missing a curable obstruction such as an impacted stone or stricture of the common duct confirmation of the diagnosis by means of *exploratory laparotomy* is usually advisable provided of course that the patient's condition, particularly with regard to liver function, shows that he has a reasonable chance of surviving the operation. Preoperative plans should include provision for the first steps of resection of the pancreas if a favorable lesion is found (Cattell, R. B. *Resection of the Pancreas. Discussion of Special Problems—* page 753).

Even in operative diagnosis of malignant disease of the pancreas some factors of uncertainty exist. Chronic pancreatitis may produce a hard mass in the head of the pancreas characteristic of a malignant growth and the surgeon may be certain he is palpating a carcinoma and close the abdomen without taking a biopsy specimen. The removal of tissue for diagnosis is hazardous and often difficult. In such a case the prognosis of a fatal outcome should include some reservations because the subsequent course may prove the condition to be benign. This pre-

caution is particularly necessary when the history is unusually long and the attacks of pain have followed the pattern of intermittent biliary colic

The following case is an example

A woman aged 69 years complained of attacks of severe right upper quadrant pain over a period of three and a half years. She had been jaundiced for three months. Her appetite was poor and she had lost 45 pounds in weight.

Physical examination revealed no palpable mass or dilated gall bladder. There was no fever. The stools showed only traces of bile. The blood sugar was normal. There was no glycosuria. Blood count showed some anemia, the hemoglobin being 66 per cent and erythrocytes 3 530 000. Roentgenologic examination showed a normal stomach with some distortion in the course of the duodenum.

The preoperative diagnosis was cholecithiasis with common duct stone. At laparotomy the liver showed signs of biliary cirrhosis. The gallbladder was small, thickened, contracted and contained stones. The common duct was dilated but contained no stones. In the head of the pancreas there was a hard nodular mass about 5 cm in diameter which the surgeon thought was a carcinoma. A biopsy was considered inadvisable. A T tube was placed in the common duct with one arm through the ampulla and the gallbladder was removed. The patient's postoperative course was uneventful and five years later she was in perfect health.

Summary—The possibility of surgical cure of carcinoma of the pancreas lends additional stimulus to accurate and early diagnosis. Certain misconceptions regarding the importance of jaundice as a diagnostic sign should be corrected and upper abdominal pain substituted as the cardinal sign of the early stages of pancreatic malignancy.

In many cases physical signs are absent but if due consideration is given to the type of pain, the anorexia and weight loss which are so uniformly present, the diagnosis should be suspected.

Roentgenologic examinations of the upper gastro intestinal tract are of distinct value in detecting pancreatic tumor. In the presence of suggestive symptoms even small distortions in the shape and course of the stomach and duodenum should be considered significant.

The jaundice associated with this disease is primarily ob-

structive but subsequent liver damage may make the character of the jaundice less clear cut

Courvoisier's law concerning the significance of a distended gallbladder is one of the best rules of diagnosis. As a physical sign it is fairly easily elicited since the gallbladder presents anteriorly and is usually easily felt and identified. A vague undentifiable mass in the right upper quadrant is usually the right lobe of the liver.

It must be admitted that the differential diagnosis of long standing jaundice is not 100 per cent reliable. Furthermore in many cases the type of obstruction cannot be positively established.

The diagnosis of carcinoma of the pancreas can be made with reasonable certainty in some cases with presumption in others and in others only on suspicion while in no case can the diagnosis be beyond the question of doubt. For this reason exploratory laparotomy should be used judiciously but widely. Practically no patient with chronic jaundice or persistent abdominal pain such as described should be denied laparotomy with the exception of those showing progressive improvement or those who cannot withstand the shock of operation.

Even with an operative diagnosis of carcinoma of the pancreas the prognosis in certain cases should include some reservations. This is because of the close similarity between some inflammatory masses in the pancreas and malignant tumors.

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SUCCESSFUL RESECTION OF CARCINOMA OF THE BILE DUCT

RICHARD B. CATTELL

PRIMARY carcinoma of the bile duct is an infrequent finding and usually the diagnosis is established only at the time of abdominal exploration for obstructive jaundice. Unfortunately extension to the gastrohepatic omentum and liver occurs early and resection is impossible because of involvement of such vital structures as the portal vein and hepatic artery. Likewise because of the rich lymphatics in this area, the regional nodes and liver usually show metastases. A circumscribed malignancy of the duct that permits any possible chance for total removal is rare.

During the last year I operated upon 1 patient in whom resection of a primary carcinoma of the bile duct appeared possible. Restoration of the continuity of the duct was accomplished by end to end anastomosis.

CASE REPORT

History—A 64 year old man was first seen at the Lahey Clinic on July 17 1942 with a complaint of indigestion and jaundice of two months duration. He had been well until January when indigestion with flatulence heartburn and fullness in the epigastrium developed. He had had no pain but a high blood pressure was noted. Two months before examination the indigestion became more pronounced and marked anorexia and a persisting metallic taste developed. He noticed that the stools were light in color and that the urine was dark. Shortly thereafter a yellow tinge of the eyes developed. During this two months period of exaggerated symptoms he lost 37 pounds in weight but had a markedly diminished food intake. His jaundice remained about the same. His past history was not revealing and he had had no operative procedures.

Physical Examination—The patient appeared to be chronically ill and showed evidence of weight loss. The height was 70 inches and the weight 168½ pounds. There was a slight icteric tint to the sclerae. The skin was dry and sallow and had a faint icteric tinge. A

few moist inspiratory rales were heard at the left base. On abdominal examination the liver edge could not be felt and there were no masses. There was a feeling of resistance without spasm in the entire epigastrium, most marked in the right upper quadrant. On rectal examination there were no hemorrhoids. The prostate gland was somewhat nodular but did not suggest malignancy. There was pitting edema of both legs and ankles. The fundi showed a grade 2 arteriosclerotic change. The blood pressure was 160 mm systolic and 100 mm diastolic.

Laboratory Examinations—Roentgenologic examinations showed no malignancy in the stomach and no increase in the curve of the duodenum. The prothrombin time was 89 per cent of normal and the carbon dioxide combining power of the blood was 48 volumes per cent. The benzoic acid liver function test with a volume of 365 cc showed a hippuric acid synthesis of 0.60 gm. Urinalysis showed a specific gravity of 1.025, no albumin, no sugar and a trace of bile. The hemoglobin was 82 per cent, erythrocytes 4,080,000 and leukocytes 7,800. The blood smear was normal. The nonprotein nitrogen was 36 mg per 100 cc, the serum bilirubin 6, the serum chlorides 577 and the blood cholesterol 376. The serum proteins were 7.2 gm per 100 cc. Gastric analysis showed free hydrochloric acid 40, total acidity 54 and a positive reaction for occult blood (guaiac 1+). The icterus index was 18. Bile was present in the urine and urobilinogen was positive to a dilution of 1:128.

Preoperative Diagnosis—Carcinoma of the pancreas or stomach with extension to the bile duct.

Preoperative Preparation—The patient was admitted to the hospital on July 17 and for seven days he was given a high carbohydrate, high protein, low fat diet, thiamine chloride, vitamin C, 300 mg, vitamin B complex and vitamin K in the form of hykinone, 3.2 mg in 1,500 cc of normal saline with 10 per cent glucose daily intravenously.

Operation—Partial resection of the common hepatic and common bile duct and cholecystectomy.

When on July 24 the patient was relaxed under pontocaine, glucose and spinal anesthesia supplemented with cyclopropane, the liver could be felt two to three fingerbreadths below the costal margin with rounded blunt edges but no nodules. There was moderate enlargement of the liver with small yellowish gray areas scattered over the surface of the right lobe. The gallbladder was contracted and contained no stones. There was a small, firm, irregular mass approximately 2 cm in diameter

involving the lower end of the cystic duct and the common hepatic and common bile ducts this involved approximately 2 cm of the main bile passage (Fig 190 *a*) The stomach duodenum and pancreas were normal There were no enlarged glands in the gastrohepatic omentum and no nodules in the liver General abdominal exploration was negative except for numerous small diverticula in the sigmoid and rectosigmoid

A right upper rectus muscle splitting incision was made Adhesions to the gallbladder were freed and the free edge of the

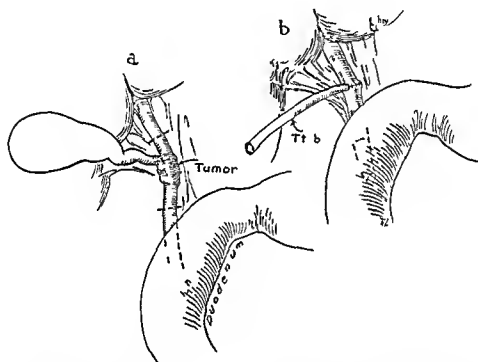


Fig 190—*a* Primary carcinoma of the bile ducts at junction of common hepatic cystic and common ducts Dotted lines show limits of resection *b* Duct reconstructed about a T tube by end to end anastomosis

gastrohepatic omentum demonstrated A diagnosis of primary carcinoma of the bile duct was made and in the absence of metastases resection was undertaken The serosa of the superior and inferior aspects of the free edge of the gastrohepatic omentum was excised The hepatic artery was exposed and displaced upward and the cystic artery severed at its origin The ducts and the mass were elevated and the portal vein dissected free throughout the gastrohepatic omentum The gallbladder was freed up from its bed leaving it attached to the mass Both right

and left hepatic ducts could be visualized as extrahepatic at the point of junction. The common hepatic duct and the common duct were sectioned 1.5 cm above and 2 cm below the lesion and the entire area removed (Fig 190 a). Anastomosis of the common hepatic duct to the jejunum had been planned but on mobilizing the head of the pancreas and duodenum the common duct could now be displaced upward to the common hepatic duct stump. Because the portions of either common hepatic or common duct were insufficient to permit bringing out the T tube through a separate incision the duct was reconstructed over a T tube emerging at the point of reconstruction (Fig 190 b). This was done without tension following which the edge of the duodenum was sutured to the under surface of the liver. A cigaret drain was brought out through the upper end of the closed incision along with the T tube. A transfusion of 500 cc of citrated blood was given at the conclusion of the operation.

Pathologic Examination—Small epithelial cells consistent with a diagnosis of carcinoma of low grade malignancy. Carcinoma of the bile ducts.

Postoperative Course—The patient made a good immediate postoperative recovery although for a few days there was a small amount of bile drainage from the wound. Bile continued to drain freely from the T tube. He was given parenteral glucose in a saline solution 1 ampule of hykinone 32 mg and vitamin C 500 mg for five days. On August 2, nine days after operation, he became irrational and took little by mouth. His nonprotein nitrogen was 145 mg per cent and his prothrombin time was 70 per cent of normal. Parenteral fluids and vitamin K were resumed and his condition rapidly improved. The nonprotein nitrogen dropped to 37 mg per cent. Bile drainage from the wound ceased and the T tube was clamped to divert the bile to the intestinal tract. His stools became well colored and his condition showed marked improvement. He was discharged from the hospital on the thirty-first postoperative day. On November 19 he had regained 35 pounds, had no digestive symptoms and had had no return of the jaundice. The bowel action was normal with good color to the stools. The T tube remained in place and was clamped off during the day and permitted to drain at night.

On January 26, 1943, there was some bile drainage from around the T tube. The T tube showed marked dilatation because of the poor quality of the rubber and the exposed portion of the tube was beginning to fragment. Accordingly, after irrigation and further

demonstration of patency the T tube was removed without difficulty. All drainage from the T tube and sinus tract ceased within forty eight hours and on February 27 his condition was reported as satisfactory.

COMMENT

In the twelve year period of 1930 to 1941 inclusive, 151 patients with malignancy of the liver bile duct and pancreas were operated upon. Of these 13 lesions were primary in the bile duct and 25 were primary in the gallbladder. No curative type of operation was carried out for primary carcinoma of either the bile duct or gallbladder since all showed metastases at the time of operation. An occasional case will probably be encountered in which primary carcinoma of the gallbladder might be removed completely but so far we have not found one. In 1939 I partially removed a pedunculated adenocarcinoma of the left hepatic duct by means of a curet. A tube was implanted in this area and the patient lived for two and a half years until death from recurrence resulted.

Malignancy of the common bile duct below the entrance of the cystic duct permits an anastomosis of the gallbladder or common hepatic duct to the gastro intestinal tract with real palliative benefit. If the common hepatic duct is involved it is commonly thought that nothing can be done except to establish an external biliary fistula. Likewise if extensive malignancy of both main ducts is found little can be done. By excising a portion of the free edge of the gastrohepatic omentum in a transverse direction the duct can be identified even though collapsed and at times it is possible to dilate the entire duct system and implant a tube. This temporarily relieves the jaundice and pruritus and makes the patient more comfortable.

The technic of removal of considerable portions of the bile duct is complicated. The same principles of repair as those employed for benign strictures of the bile duct are applicable (Cattell R. B. Benign Strictures of the Bile Ducts—page 701). In the operation recorded here the T tube was brought out at the line of suture which is a definite disadvantage. One could consider the use of a vitallium tube or an implanted rubber tube in continuity with the duct or the stump of the hepatic duct could be joined to the duodenum or jejunum. In our patient the T tube was to be left in for one or two years but because

of the poor rubber it was felt necessary to remove it six months later. The immediate result of resection in this case is good. Because the patient was a poor risk he had a somewhat prolonged hospital stay but did well except for a short period of three or four days. What the ultimate result will be is a question but stricture at the site of anastomosis and recurrence of the malignancy must be considered as possibilities.

SUMMARY

Primary malignancy of the main bile passages is rare. The diagnosis is made only at the time of exploration. A successful resection of a primary carcinoma of the common hepatic cystic and common bile duct is reported seven months after operation.

RESECTION OF THE PANCREAS DISCUSSION OF SPECIAL PROBLEMS

RICHARD B CATTELL

THE removal of portions of the pancreas brings up special problems both physiologic and technical. A resection of the pancreas should offer a definite possibility of cure since a palliative effect can be accomplished by a much less formidable procedure. Small portions of the pancreas can be removed for diagnostic purposes by an approach through the gastrohepatic omentum. Likewise a benign hyperfunctioning tumor if it can be localized can be removed without danger of interruption of the main pancreatic ducts. At times because of cystic or calculous change removal of a portion of the pancreas may be necessary but such a procedure rarely needs be undertaken because of a penetrating wound or other trauma. The removal of a malignant tumor of the pancreas is difficult and involves special problems.

The removal of a malignant tumor of the tail or distal half of the body of the pancreas should offer no unusual technical difficulties. Unfortunately a tumor in this portion of the pancreas is rarely operable since recognizable symptoms occur so late that metastatic spread usually has occurred. At times a carcinoma involving the ampulla or papilla of Vater and the head and proximal part of the body is resectable. Removal is complicated by the close association of the duodenum and by the fact that the surgeon must deal with the main bile ducts and main pancreatic ducts. Since obstructive jaundice occurs early carcinoma in this location may be found in an operable stage.

A review of a series of our cases by Drs Kiefer and Moravec appears on page 738 of this volume. The purpose of this paper is to discuss some of the special problems associated with removal of carcinoma of the ampulla and head of the pancreas.

DIAGNOSIS

In patients with painless obstructive jaundice the diagnosis of carcinoma of the head of the pancreas or ampulla of Vater

must be considered. Proof must usually wait until abdominal exploration. Since the Lahey Clinic policy is to explore all patients with obstructive jaundice, cases suitable for resection are found as soon as possible. Persistent high back pain is a common symptom in long standing malignancy of the pancreas but is more suggestive of extension. Abnormal fat digestion may be a suggestive finding. Courvoisier's law is valuable in differentiating malignancy of the lower common duct or head of the pancreas from common duct stone and palpation of a distended gall bladder in the presence of painless jaundice gives a presumptive diagnosis of carcinoma. Rarely during an operable stage will a pancreatic mass be felt.

Laboratory procedures that help in establishing a diagnosis include duodenal drainage. The presence of blood in the duodenal contents, the absence of bile or the absence of cholesterol crystals and bilirubin pigment suggests malignancy. Rarely will malignant cells be found. An increase in the blood amylase can be expected. Pancreatic functional tests are not sufficiently accurate to be of help but the determination of the fragility of the erythrocytes, serum bilirubin and icterus index and abnormalities of the prothrombin test are all useful. Occult blood may be found in the stool.

Visualization of the stomach and duodenum by *roentgenologic examination* after the administration of barium may reveal some distortion of the duodenum or show an increase or widening of the duodenal curve (Kiefer and Morawec—page 738). This offers the only possible roentgenologic means of aiding in the diagnosis since the Graham test is of no use. It should be remembered that in malignant obstruction of the lower end of the common duct, common duct stones as a primary or secondary result may be present.

Abdominal exploration is the means of establishing diagnosis. Dilatation of the biliary tract with a miss in the region of the second portion of the duodenum or head of the pancreas strongly suggests malignancy. A biopsy specimen of glands in the gastrohepatic omentum particularly if they are enlarged should be taken. Exploration of the common duct is rarely necessary although fragments of malignancy might be obtained by curet through a choledochostomy incision. More valuable is a transduodenal approach to the ampulla of Vater with a biopsy.

specimen from this area is described in Trimble's⁴ case. In our experience biopsy of the pancreas has proved unsatisfactory and unreliable. If a positive report is obtained the surgeon can proceed with assurance; however the likelihood of a cure is decreased when the malignancy involves the superficial portions of the pancreas. In our experience it is usually necessary to proceed with a duodenopancreatic resection without the benefit of a positive biopsy.

PREOPERATIVE PREPARATION

Careful rehabilitation of a patient with carcinoma of the pancreas is essential for a successful outcome. In most cases the same preparation is required as in nonmalignant obstructive jaundice (Ralph Adams—page 673) although a period of one to three weeks may be required. The diet should have a high carbohydrate high protein content with particular emphasis on dairy proteins. Fats should be excluded. A large amount of fluids should be given and care taken to establish a normal electrolytic balance. Vitamin C 300 mg daily and vitamin B complex are given. Vitamin K should be administered parenterally in all cases even when the prothrombin time is normal. In the presence of anemia whole blood transfusions are given. Before operation determinations of the blood chlorides serum proteins and blood cell counts should be made to insure their being within reasonably normal limits.

ANESTHESIA

All patients are operated upon under spinal anesthesia. If the surgeon decides preoperatively to perform the operation in two stages the first operation is performed under pontocaine glucose anesthesia. All operations involving actual resection are performed under fractional or continuous spinal anesthesia. This form of anesthesia described by Lemmon⁵ has been of the greatest importance in maintaining patients in good condition throughout the operation while at the same time offering the best operative conditions.

OPERATIVE PROBLEMS

As previously mentioned the *first* problem at operation is to establish the diagnosis. This is usually done by palpation and

inspection and may include biopsy and examination of a frozen section

The *second* problem is whether the operation will be done in one or two stages. In our opinion a patient who is deeply jaundiced or is a poor operative risk should have a two stage operation. Patients in good condition with mild or no jaundice are suitable candidates for a one stage pancreaticoduodenal resection.

The *third* decision concerns operability. If there are metastases to the regional lymph nodes particularly in the gastrohepatic omentum or any evidence whatever of metastases to the omentum peritoneum or liver radical removal should not be considered. The operation is too extensive and too hazardous for unfavorable cases. It may be impossible to determine by means of palpation and inspection whether the lesion is operable. Metastasis to the splenic superior mesenteric or portal veins or to the superior mesenteric artery is one of the most likely extensions and must be ruled out before the operative procedure is too far advanced. In my experience this can be accomplished by freeing up the pyloric end of the stomach and the first and second portions of the duodenum without interruption of the gastro intestinal tract or the common bile duct. Blunt dissection can then be carried from the superior aspect beneath the pancreas by dissection of the gastrohepatic omentum to demonstrate that the portal superior mesenteric and splenic veins can be freed from the pancreas. Similarly dissection of the third portion of the duodenum and inferior aspects of the pancreas can be done bluntly to show that the superior mesenteric vessels are not involved. If these areas are free of malignant extension the pyloric end of the stomach and common duct can be divided following which the pancreas can be sectioned at the proper location. This order of dissection is important since if there is posterior extension the operation can be stopped the stomach and duodenum and head of the pancreas dropped back and a palliative cholecystojejunostomy done without too seriously endangering the life of the patient. On two occasions I have terminated the operation at this point without fatal results.

The *fourth* decision concerns selection of the type of operation. Many different one stage and two stage operative procedures have been described by Whipple⁵ Hunt⁶ Trimble⁴

and others. If a two stage operation is chosen, the first stage should be such as to avoid adhesions or additional technical difficulties at the second stage. In my opinion this means that the common duct should not be utilized for anastomosis during the first stage and the gastro intestinal anastomosis should be left for the second stage. The avoidance of technical difficulty as a result of the first stage is best accomplished by an antecolic cholecystojejunostomy utilizing an 18 to 20 inch loop. Thus the gastrohepatic omentum and duodenum are left untouched and this loop of jejunum is displaced at the second stage. The two stage operation permits satisfactory rehabilitation of the

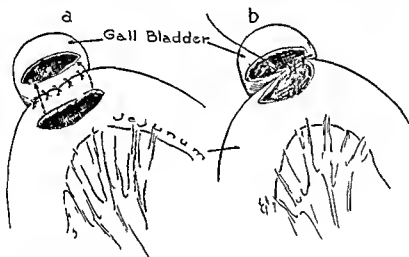


Fig 191—*a* Cholecystojejunostomy. Interrupted nonabsorbable sutures are placed. An anastomosis with a large opening is made. *b* The mucosa is carefully approximated to avoid later stricture. This is the first stage of the two stage operation.

patient which can be continued for any required length of time. From a survey of our cases I feel that the two stage operation is indicated in the majority of patients.

At the Lahey Clinic we perform a cholecystojejunostomy if a two stage operation is undertaken. We prefer anastomosis to the jejunum rather than to the duodenum or stomach, either of which would interfere with the subsequent stage. A long loop antecolic anastomosis is performed with an enterostomy about 7 inches from it. It is important that a large opening be made in the gallbladder (Fig 191 *a*) since with the relief of biliary pressure considerable shrinkage at the anastomosis

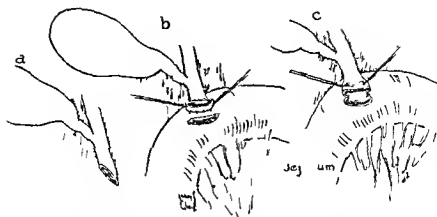


Fig. 19—A. Incision of the omentum to the jejunum. a. Oblique incision of the omentum to make a larger incision. b. Interrupted sutures for the first layer of the anastomosis. Traction sutures prevent narrowing. c. The anastomosis approximated accurately. The anastomosis is completed. The jejunum is shown in Figure 194. This is the method of anastomosis of the bile duct in the stomach procedure.

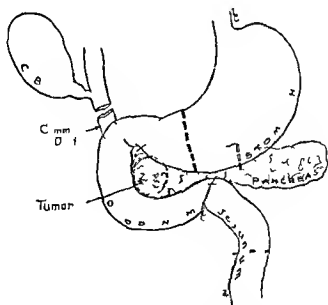


Fig. 193—Location of pancreatic duct relative to the first part of the pancreas. The dotted line in the pancreatic duct of the stomach in the body of the pancreas and in the upper jejunum is the location of the common duct. The line is the location of the block.

will take place. If an open anastomosis is done it is unnecessary to use a tube. Great care is taken to get the mucosa of the gall bladder to the mucosa of the jejunum (Fig 191 *b*). At the second stage the common duct is inverted carefully avoiding obstruction to the cystic duct. Simple ligation of the common bile duct may result in a bile fistula. In a one stage operation the bile tract anastomosis is between the common bile duct and the

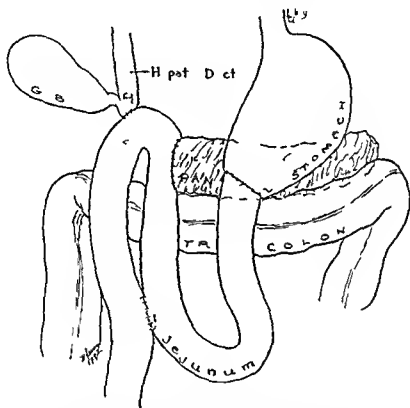


Fig 194—The completed one stage pancreaticoduodenectomy consisting of an antecolic end to-end gastrojejunostomy end to side pancreaticojejunostomy end to side choledochojejunostomy and jejunojejunostomy

jejunum over a tube (Figs 192 and 194). This eliminates the necessity of two suture lines in the biliary tract as would be the case if the gallbladder were used.

Two different gastro intestinal anastomoses have been employed at the Lahey Clinic. In our one stage operation the pyloric end of the stomach, all four portions of the duodenum and a small proximal portion of the jejunum are removed (Fig 193). This is done by dividing the jejunum beyond the ligament

of Treitz and then displacing the fourth portion of the duodenum and proximal part of the jejunum under the superior mesenteric vessels delivering them to the right of these vessels. Under these circumstances an end to end antecolic gastrojejunostomy is carried out (Fig 194). If the fourth portion of the duodenum is left in place and the duodenum turned in behind the superior mesenteric vessels (Fig 195) the end of the stomach is anastomosed to the side of the jejunum again in an antecolic position (Fig 196). In these operations it is our aim to divert the food away from both the pancreatic and the biliary anastomoses. This is accomplished either by the anasto-

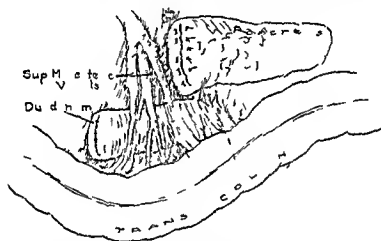


Fig 195.—In carcinoma of the ampullar part of the third and all of the fourth portions of the duodenum are left in place. The duodenum is turned in just to the right of the superior mesenteric vessels.

mosis of the stomach to the jejunum below the other anastomoses or by means of a jejunojejunostomy in a similar position (Fig 194).

The most serious problem associated with pancreaticoduodenal resection is the management of the external secretion of the pancreas. It has been said repeatedly that preservation of the external secretion of the pancreas or its diversion to the intestinal tract is unnecessary. I believe that most of the serious complications and perhaps the greater number of postoperative deaths have been due to complications of an external or internal pancreatic fistula. Even though both the ducts of Santorini and Wirsung

are ligated, it seems likely that considerable discharge of external pancreatic juice from the closed cut surface of the pancreas will occur and unquestionably some of the ligated ducts will open up. Various technical steps for the avoidance of a pancreatic fistula have been advanced among them the suggestion of Hunt of burying the closed end of the pancreas in the open end of duodenum or jejunum. In our technique which has been successful in avoiding external pancreatic fistula we use the

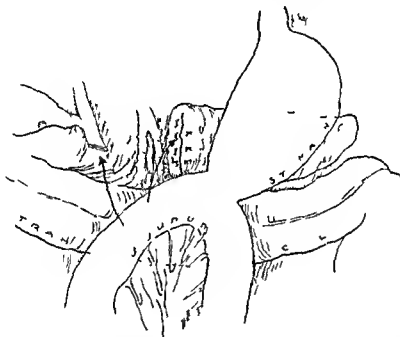


Fig 196—In a one stage operation for carcinoma of the ampulla when the third and fourth portions of the duodenum are left in place the gastrointestinal anastomosis is completed by an antecolic end to side gastrojejunostomy. The operation is completed by pancreaticojejunostomy and choledochojejunostomy in the position indicated by the arrows.

different loop of jejunum going to the biliary jejunal anastomosis to continue the closed end of the pancreas. This can be done (1) by buttressing this loop of jejunum against the closed end of the pancreas (2) by scarifying the serosa or (3) by actually anastomosing the main pancreatic duct to the jejunum (Fig 197). In one patient we found sufficient dilatation of the main duct of the pancreas to do a direct anastomosis over a tube. Although usually this duct is small it can be identified readily and probed. We now recommend that this anastomosis be ac-

removed in carcinoma of the ampulla or papilla (Fig 198) and the entire head, neck and half the body should be removed if the head of the pancreas is involved (Fig 193). If a considerable portion of the tail is left it will supply all the internal and external secretion needed and the removal of the larger portions of the pancreas do not materially increase the operative mortality and do offer a much greater chance for cure. Removal of only small portions of the duodenum with smaller portions of the pancreas is insufficient. Resection of the pyloric end of the stomach and at least the first, second and third portions of the duodenum are required for carcinoma of the ampulla and if the carcinoma is in the head the remainder of the duodenum should also come out (Figs 193 and 198). A sufficient portion of the common duct must be left to make an anastomosis without involving the cystic duct (Figs 193 and 194).

The two *further* problems which exist in any extensive procedure are the avoidance of hemorrhage and shock. Hemorrhage is best avoided by ligation of vessels at their point of origin. As the duodenum is freed up the gastroduodenal artery can be identified and divided just below the hepatic artery. The right gastric and right gastroepiploic arteries are ligated as is the superior pancreaticoduodenal artery. In the inferior dissection the first branch of the superior mesenteric artery and the inferior pancreaticoduodenal artery are ligated. Fortunately there are rarely venous branches before the splenic and superior mesenteric veins come off the portal vein. The various smaller vessels supplying the pancreas must be controlled separately. In order to avoid postoperative hemorrhage the gastrohepatic omentum should be reconstructed so far as possible over the arterial stumps and drainage in this area avoided. The usual means of combating surgical shock fortunately are available.

Pancreaticoduodenal resection is time consuming, requiring from two and a half to five hours. Continuous or fractional spinal anesthesia is of great help and supportive drugs such as pitressin and ephedrine when indicated will help. Arrangements should be made preoperatively for continuous administration of fluids and glucose by needle or cannula and for two transfusions during the operation.

POSTOPERATIVE CARE

The patient is placed in an oxygen tent for several days post-operatively. If bronchial secretions accumulate bronchoscopic suction is carried out. He is moved at frequent intervals and encouraged to hyperventilate the lungs. The prothrombin time is checked every two days and the vitamin K preparation hykinone, 3.2 mg. is given daily parenterally. The electrolytic balance and serum protein are followed closely. Feedings are carried out by a Levin tube through the gastro intestinal anastomosis. Through this large quantities of food can be given and to prevent distention suction can be connected as indicated. In addition to vitamin K vitamin C 500 mg. daily parenterally with glucose salt solution and amino acids are given. We consider it unnecessary to administer bile salts, whole bile or pancreatic substitution therapy. For a similar reason we use no lipocaine.

CLINICAL EXPERIENCE

During 1942 4 patients had radical pancreaticoduodenal resections; there was no death. Two were one stage and two were two stage procedures. A first stage operation was performed on 2 patients with the idea of a subsequent resection. One refused the second operation and the other later had demonstrable extension of malignancy and operation was not advised. Two other patients had a first stage operation and a second stage attempted but the operations were discontinued because the superior mesenteric vessels were invaded by malignancy. One additional patient has had the first stage operation and will have the second stage in a short time. This appears to be a favorable case. Also during 1942 Dr. Marshall of the Clinic staff resected the tail of the pancreas successfully for a benign hyperfunctioning adenoma. Twenty one additional patients were explored but only palliative cholecystojejunostomy or other palliative operations were performed. The only other patient having a radical resection was operated upon in 1939 and died seventeen days after the second stage operation.

SUMMARY

Special problems concerned with the diagnosis and surgical removal of the pancreas and duodenum for carcinoma have been presented. With increasing experience and improved prospects for successful removal of carcinoma of the pancreas and ampulla

this field of surgery will be extended. It is reemphasized that at times pancreaticoduodenal resection must be carried out without a confirmed diagnosis of malignancy because of the inadequacy of biopsy and frozen section. Technical steps in both the one and two stage operations for carcinoma of the pancreas and ampulla are presented. Attention is directed to the importance of avoiding a pancreatic fistula both internal and external and means for their prevention are shown.

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THE DIAGNOSIS OF BORDERLINE HYPERTHYROIDISM

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With the advent of war there apparently is an increasing number of cases simulating hyperthyroidism. During World War I many soldiers with neurocirculatory asthenia, irritable heart or soldier's heart were thought to have hyperthyroidism. Increased stress and strain may also affect civilians, particularly those whose husbands, brothers or sons are in the armed services.

NEUROCIRCULATORY ASTHENIA

Neurocirculatory asthenia is the most common disorder to be confused with hyperthyroidism. In most cases the diagnosis should be made on the basis of the history. Palpitation, tachycardia and tremor are the chief symptoms consistent with either diagnosis. Weight loss may occur in either condition, but the caloric intake of the patient with neurocirculatory asthenia is usually insufficient and thus accounts for the weight loss. In contrast, the patient with hyperthyroidism maintains or increases his food intake, but weight loss persists. In a few cases of hyperthyroidism the weight may increase because of added food intake and/or restriction of activities. Loss of appetite may occur late in the course of hyperthyroidism in elderly patients or because of anorexia-producing medication.

The variable degrees of activation in hyperthyroidism are quickly recognized by the physician who sees many such patients. The possibility of hyperthyroidism is greatly increased in the presence of definite eye signs such as stare, infrequent blinking and varying degrees of exophthalmos, which constitute part of the general appearance of the hyperthyroid patient. These signs are absent in nervous patients.

The patient with neurocirculatory asthenia may have a fine tremor, but in contrast to the patient with hyperthyroidism, the warmth of the skin is not striking; in fact, the skin may be cold and abnormally moist. The warm, moist skin of hyperthyroid patients may not be impressive in a cold environment, but under most circumstances it is a useful diagnostic aid.

Shortness of breath may be present in either condition but usually frequent sighing or difficulty in taking a deep breath is what the neurocirculatory patient means by shortness of breath. Tachypnea occasionally is present in the hysterical type of patient; the nature of this abnormal breathing may be suspected because of its occurrence at rest or during emotion or if following exertion it is out of proportion to the effort undertaken.

Palpitation is not at all distinctive. The height of the blood pressure in patients with neurocirculatory asthenia is variable and consequently is of no help in diagnosis. Hypertension may occur with neurocirculatory asthenia particularly in those age groups in which hypertension is prevalent. The pulse pressure is of more importance. In hyperthyroidism the diastolic pressure averages lower than normal and as one observes the blood pressure reading one can hear a snapping of the pulse waves as the diastolic pressure is approached. This phenomenon is found also in aortic regurgitation or may be present occasionally in elderly patients with arteriosclerosis. The impulse or heart thrust of a patient with hyperthyroidism is forceful and easily palpated even at rest although occasionally patients with severe neurocirculatory asthenia may have such violent palpitation that it is not always valuable in differential diagnosis.

Patients with hyperthyroidism usually feel well, sleep well and have good appetites particularly when at rest but the patient with neurocirculatory asthenia usually complains of insomnia and lassitude even at rest. The hyperthyroid patient is often eager to be active but his endurance is limited.

The importance of palpating the thyroid gland should be emphasized. The majority of patients with hyperthyroidism have an abnormal thyroid gland. Although the gland may not be enlarged it is usually firm or occasionally pebbly in consistency in at least 98 per cent of cases. Although true exophthalmic goiter with exophthalmos might occur with a substernal adenomatous goiter to my knowledge we have not observed it. Generally speaking if the patient has clinical evidence of exophthalmic goiter and the thyroid cannot be palpated an intra-thoracic goiter need hardly be suspected. The normal thyroid should be palpable but at times because of the short thick neck of the patient it may be impossible. A typical history revealing

increased appetite and adequate consumption of food with weight loss a sensation of warmth tremulousness palpitation eye signs and an elevated basal metabolic rate is practically conclusive evidence of hyperthyroidism even if the gland can not be palpated

In females there is often a diminution of the menstrual flow and sometimes complete amenorrhea Excessive flowing does occur but is probably incidental

In men past 50 years of age there is often a discrepancy between the basal metabolic rate and the rapidity of the pulse in spite of the elevation of metabolism the pulse may not be significantly increased if at all A wide pulse pressure in these cases is the rule

In the differential diagnosis of neurocirculatory asthenia and mild or borderline hyperthyroidism the basal metabolic rate is often helpful A few exceptions however must be kept in mind namely the presence of other disease which might produce an elevated basal metabolic rate If the metabolism and pulse are found to be elevated on one day and on the subsequent day are found to be normal the likelihood of hyperthyroidism is remote The possibility of the existence of hyperthyroidism when normal metabolic rates are obtained is certainly less than one in a hundred and even in such cases the results obtained will be somewhere between +5 and +15 per cent

If after repeated tests a question of hyperthyroidism still exists because of such borderline basal metabolic rates obviously the disease is mild and immediate subtotal thyroidectomy is unnecessary In such a case one may let the patient return to normal activities and then decide during ensuing months whether hyperthyroidism exists If present the disease will probably increase in severity so that it is easily recognized

EXOPHTHALMOS

Many individuals develop severe hyperthyroidism without exophthalmos and some may even develop only unilateral bulging Some develop exophthalmos but appear to have no other evidence of hyperthyroidism Between these two extremes are all possible variations Marked edema with little actual exophthalmos may be seen in both groups

Thyrotropic hormone from the pituitary can be used to pro

duce hyperplasia of the thyroid in animals and in vitro and even exophthalmic goiter by repeated and increasing doses. The patients in whom exophthalmos is the predominant sign and in whom there is little or no clinical hyperthyroidism are said to show thyrotropic hormone in the urine and by the use of tagged iodine or radioactive iodine little if any ability of the thyroid to take up iodine is demonstrated. Attempts have been made to separate those cases with little or no hyperthyroidism in which eye signs are predominant³ from those in which hyperthyroidism alone is the source of illness or symptoms. Long ago we learned to avoid surgery in those cases with exophthalmos which do not have clinical hyperthyroidism. The classification of these cases on the basis of finding thyrotropic hormone in the urine or indirectly in the blood⁴ is an ingenious idea but one which is yet cannot be accomplished for clinical purposes. It is no more logical to classify these cases solely on the basis of iodophilic or noniodophilic capacity of the thyroid gland than it is to attempt to separate them on the basis of the basal metabolic rate. We prefer to consider these cases from the extreme of severe exophthalmos without hyperthyroidism to severe hyperthyroidism without exophthalmos with all intermediate variations as end results of a primary and unknown cause.

Thus in some of these exophthalmic cases the question of clinical hyperthyroidism arises. Exophthalmos is ordinarily acceptable evidence of the presence of exophthalmic goiter but it should not weigh too heavily in this type of case in making the decision as to subtotal thyroidectomy because the eyes will probably not recede after operation. Postoperative myxedema particularly should be avoided so that unless there is fairly conclusive evidence of generalized hyperthyroidism surgery is not undertaken.

HYPERTENSION

Hyperthyroidism might also be suspected in the hypertensive patient. In the severe progressive malignant type of hypertension there is often slight exophthalmos, tremor and tachycardia and also increased nervous tension suggesting the activation of the hyperthyroid patient. Weight loss however is not usual except when so called hypertensive diets are used. Palpitation is a frequent complaint and with the high diastolic pressure and eye ground changes the evidence favors hypertension.

alone. With a diastolic pressure of 130 to 160 mm. Hg. as may be present in these cases hyperthyroidism is extremely unlikely. A basal metabolic rate approaching +50 per cent may be present without hyperthyroidism. If well marked clinical hyperthyroidism and hypertension are both present, the hypertension will persist even after operation.

An overactive heart thrust in spite of the high blood pressure is not conspicuous in hypertension. The snapping pulse waves as heard on auscultation of the blood pressure in hyperthyroidism are absent in hypertension. Gallop rhythm is often present in hyperthyroidism particularly if the patient is severely toxic but usually disappears after a few days rest in bed. Experience with total ablation of the thyroid has shown that the elevated metabolism found in some cases of hypertension persists after ward.

When a hypertensive patient has enlargement of the thyroid which might occur where endemic goiter is prevalent the question of hyperthyroidism is more justly raised. In general one should be very suspicious of a diagnosis of hyperthyroidism with a high diastolic blood pressure. The majority of these patients do not have hyperthyroidism but as stated previously the two conditions may be associated.

HEART DISEASE IN PRESENCE OF COLLOID OR NOCULAR GOITER WITHOUT HYPERTHYROIDISM

The forceful apex impulse produced by mitral stenosis and the patient's consciousness of this overactivity have led physicians to suspect hyperthyroidism especially in the presence of an enlarged thyroid or a prominent transverse fold of fat. Hyperthyroidism and mitral stenosis may be associated both being predominantly diseases of women. In moderately severe hyperthyroidism mitral stenosis might be suspected because of the prominent cardiac impulse and at times a presystolic sound which has been called the functional mitral stenosis of hyperthyroidism. We have seen a number of patients with mitral stenosis who had been told that they had hyperthyroidism.

Paroxysmal tachycardia may be confused with or thought to be due to hyperthyroidism. If present there usually is no clear cut history of paroxysms in the past or for that matter during active hyperthyroidism. On the other hand paroxysmal auricular fibrillation or flutter should always lead one to suspect

hyperthyroidism since over 10 per cent of all patients with toxic goiter develop auricular fibrillation at some time or other during the disease. It becomes established permanently before operation in from 3 to 5 per cent of cases.

On several occasions the tachycardia and gallop rhythm after coronary thrombosis has brought up the question of hyperthyroidism. The sweating which sometimes occurs with coronary disease leads one to suspect the presence of toxic goiter. When a nodular nontoxic goiter is present the problem is a difficult one. Hypertension and at times congestive changes may contribute toward an elevated metabolic rate. In these cases no other diagnostic data are of more importance than the history. One dislikes to overlook the possible help to be afforded by subtotal thyroidectomy if some degree of hyperthyroidism is present and such cases require the utmost in diagnostic acumen on the part of the physician. Present day anesthesia greatly reduces the increased risks incidental to surgery in the presence of coronary disease but in general it is better not to operate if there is considerable doubt of hyperthyroidism.

HYPERTHYROIDISM SIMULATING PRIMARY HEART DISEASE

We wish to reiterate that many patients have been thought to have heart disease alone when the precipitating cause of the symptoms was hyperthyroidism. The frequency of auricular fibrillation, the presence of congestive heart failure, particularly where auricular fibrillation is present, overshadow the underlying hyperthyroidism. Usually a fairly characteristic history of hyperthyroidism is present as well as other diagnostic physical findings. This group of patients has been termed thyrocardiac. In these cases a radical subtotal thyroidectomy is justified when there is an element of doubt concerning the diagnosis of hyperthyroidism since the chance of improvement is great if the latter is present. In the patient with borderline hyperthyroidism without cardiac complication the prognosis is less favorable; one hesitates to delay in the former instance but can afford to do so in the latter.

HYPERPITUITARISM

Hyperthyroidism may be present in patients with a hyperfunctioning pituitary tumor or acromegaly. In a few instances

hyperthyroidism may be the predominant metabolic disorder and it might occur before acromegalic changes are recognized. Most patients with acromegaly have changes in the thyroid gland either adenomatous or hyperplastic. Exophthalmos in such cases has not been observed in this Clinic. The sella turcica is practically always enlarged so elimination of a hyperfunctioning pituitary tumor by roentgenogram is relatively simple. In some 50 per cent of patients with acromegaly the basal meta-



Fig 199—Acromegaly with severe hyperthyroidism. Note diffuse nodular and hyperplastic enlargement of thyroid. Weight loss 50 pounds. Basal metabolic rate +81 per cent. Weight 145 pounds. Recovery of weight to 189 pounds seven months after subtotal thyroidectomy.

bolic rate may be elevated but clinical evidence of hyperthyroidism is uncommon. In patients with acromegaly and severe hyperthyroidism who have lost considerable weight, subtotal thyroidectomy may be done with excellent results in correcting symptoms of thyroid origin (Fig 199). Apparently it does not affect the progress of acromegaly.

PARKINSON'S DISEASE

In Parkinson's disease one often suspects hyperthyroidism. There is a definite stare with masked facies but the usual activa-

tion of hyperthyroidism is absent. Coarse tremor usually of the pill roll type is frequently present. These patients may have enlarged thyroids and be suspected of hyperthyroidism. They might gradually lose weight in spite of a good appetite. The inability to relax and the rigidity caused by the Parkinson's disease may cause elevation of the basal metabolic rate. The diseases are occasionally associated. One cannot expect the symptoms of Parkinson's disease to improve following subtotal thyroidectomy, but the cure of symptoms due to hyperthyroidism may be expected.

TUBERCULOSIS

Although the need of differentiation between tuberculosis and hyperthyroidism has always been pointed out, it is not an important problem. The recognition of tuberculosis in the presence of hyperthyroidism or vice versa is of greater concern. Pulmonary tuberculosis progresses more rapidly when hyperthyroidism is present and in our experience satisfying results have followed the relief of hyperthyroidism.

MISCELLANEOUS DISEASES

Leukemias, *polycythemia vera* and *periarteritis nodosa* also commonly cause an elevated metabolism. The differentiation of these conditions which ordinarily should be easy is important chiefly when an enlarged thyroid is present. We have seen a patient with true exophthalmic goiter with *periarteritis nodosa* who was benefited after subtotal thyroidectomy. The disease has remained latent since that time.

True psychoses may be present in patients with hyperthyroidism. If the hyperthyroidism is severe the psychosis may have been precipitated by it, but if a mental disorder existed before the onset of hyperthyroidism one cannot expect too much from subtotal thyroidectomy. Sometimes a patient goes into a psychotic state following operation and in these cases the prognosis is better. Psychotic patients without hyperthyroidism may show some semblance of the so called thyroid facies, anxiety state, stare, tremor or other symptoms suggesting hyperthyroidism, however the infrequency of hyperthyroidism with the psychotic state makes any patient with psychosis an unlikely candidate for this disease.

INDUCED HYPERTHYROIDISM

We have had experience with a few patients who have taken desiccated thyroid for one reason or another and some of these patients failed to volunteer this information. When the thyroid gland is normal in size, shape and consistency with no eye signs present and some psychic abnormality in the background is suspected the possibility of the secret self administration of



Fig. 200—Exophthalmos following the oral administration of desiccated thyroid. Approximately 3 grains USP daily for several years for obesity. Basal metabolic rate —6 per cent while on this dosage. Eyes did not recede when desiccated thyroid was stopped.

thyroid should be considered. One might have to go to extreme lengths to verify this suspicion. Hospitalization and careful elimination of all possible sources of desiccated thyroid will cause the metabolic rate to fall as the patient's supply is shut off.

Another helpful procedure is the estimation of the blood iodine. The blood iodine in severe hyperthyroidism does not reach the heights to which it may rise on taking iodine or desiccated thyroid. The return of the blood iodine to a normal level under strict observation also helps to verify the suspicion of self medication. A few patients take desiccated thyroid on prescrip-

tion thinking it is some sort of medicine for thyroid trouble. Increased nervousness and elevation of metabolic rate may result so the physician should inquire as to the type of medicine being taken and its bearing on the patient's illness. These patients appear thyrotoxic and even though they think the medicine is for goiter all their symptoms begin after taking it. We have seen only 7 patients (Fig. 200) develop mild and persistent exophthalmos without hyperthyroidism while taking desiccated thyroid. In another case a mild hyperthyroidism controlled by iodine accompanied the development of exophthalmos.

IODINE IN RELATION TO DIAGNOSIS OF HYPERTHYROIDISM

As a diagnostic aid iodine in the form of Lugol's solution has been recommended but to be of practical value in borderline cases a series of at least three basal metabolic tests on successive days should be done to determine the base line. Then 10 to 20 minims of Lugol's solution should be given daily for at least three weeks. A drop in the basal metabolic and pulse rates, a gain in weight as well as clinical improvement should mean that iodine has been beneficial. To prove the point in borderline cases medication should be discontinued until hyperthyroidism returns. The temptation is to continue with iodine as long as a good result is obtained. The disease may run its natural course subsiding in a few patients but progressing in a greater number in spite of iodine eventually necessitating subtotal thyroidectomy. A definite diagnosis should be established as soon as possible and operation undertaken.

Patients who have received iodine before their first examination also present borderline cases of hyperthyroidism particularly if a good iodine effect has resulted. Often there may be little evidence on which to base a diagnosis of hyperthyroidism just as when iodine is given as a therapeutic test. If exophthalmos is present this in all probability will persist but the pulse may be normal, the tremor gone and the metabolism normal. If the thyroid gland is firm and hard iodine involution has probably taken place but subtotal thyroidectomy should not be advised until the diagnosis is fairly certain. Chronic thyroiditis may present a firm, hard gland indistinguishable from involution. Then too coincident adenomatous changes may interfere with an accurate appraisal of the gland after iodination. Thus since

the patient has lost most of the objective findings, one can afford to mark time and stop the use of iodine for a period of four to twelve weeks. If the patient had hyperthyroidism beforehand the symptoms of the disease will return and then the diagnosis is established.

RECURRENT HYPERTHYROIDISM

There is always a possibility of recurrent hyperthyroidism. We have seen this occur in patients with postoperative myxedema and in others who were in normal health over a period of years following subtotal thyroidectomy. At first the clinical evidence for recurrence may be small but generally speaking enlargement of the thyroid remnant is present. Enlargement may occur at the isthmus or at the lateral aspect of each lobe. In earlier days the tip of the lobe was left behind and often the pyramidal lobe was not removed. Hyperplasia of the remnant or remnants may be found in those regions. Sometimes such hyperplastic remnants may be mistaken for a lymph gland. If the patient developed a low metabolism postoperatively and in subsequent years had recurrence of clinical hyperthyroidism he may have had hyperplastic remnants some time before clinical symptoms of actual hyperthyroidism developed. In other words the basal metabolic rate rises gradually to normal but clinical symptoms may not appear until it exceeds the normal range. In several cases we have been able to predict recurrent active hyperthyroidism in view of the finding of hyperplastic remnants and the elevation of the metabolism above previous levels although not above the normal average range. The administration of iodine in these cases is justified. In rare instances mild myxedema may result.

EFFECT OF SEDATION ON BASAL METABOLIC RATE

The use of sedatives in borderline cases has been helpful. The clinical findings and history with the elevated basal metabolic rate should enable one to make the final diagnosis. However if the basal metabolic rate is from +15 to +30 per cent one hesitates to advise subtotal thyroidectomy or to dismiss the diagnosis of hyperthyroidism entirely.

Sedation in the form of barbiturates two to three hours before the test so that the patient is virtually asleep eliminates a certain

number of patients as having thyroid disease. Several years experience with this method has proved it to be helpful although not definitely diagnostic. For example some patients who definitely do not have hyperthyroidism even with sedation will not show a return of the metabolic rate to normal although it may be greatly reduced. Even in hyperthyroidism sedation may produce some reduction of the basal metabolic rate due to the decrease of nervousness but it tends to remain elevated.

LABORATORY AIDS IN DIAGNOSIS

Basal Metabolic Rate—In hyperthyroidism the basal metabolic determination is the most practical procedure in diagnosis; however there are certain pitfalls. First leakage may take place increasing the apparent consumption of oxygen. This is particularly apt to occur in persons with dentures which fit poorly and may occur in spite of negative routine tests for leakage. Secondly worn out soda lime may prevent the absorption of carbon dioxide with an apparent decrease in oxygen consumption thus giving an approximately normal result when the rate actually is elevated. Thirdly the patient should be at ease during the test and should be reassured. The nose piece should fit properly and if there is any discrepancy the test should be repeated. We give most patients a sedative the night before the test and insist that the patient spend the preceding night in the hospital. It has been shown that the average metabolic rate taken after a night's rest in the hospital is from 10 to 15 per cent lower than that taken when the patient sleeps at home and in the morning comes to the office or the laboratory for the test.

Some persons can never adapt themselves to the test. Frequent sighing during the metabolism test always suggests the possibility of a nervous disorder. Another point to be considered is a miscalculation of the rate by the technician. If possible every test should be checked by another person.

The physician should be alert to discrepancies such as an elevated metabolism with a pulse rate of 60 or 70 except as before noted or a low metabolic rate where there is good clinical evidence of hyperthyroidism. Furthermore he should remember that the metabolic rate varies in different patients; that the normal standard is merely an average; that the metabolic test in elderly patients is probably lower than the standards.

given and that many persons who are perfectly well may have rates above but especially below the normal range

Blood Iodine—Although the blood iodine is increased in hyperthyroidism one would hesitate to make a diagnosis solely on this basis since the content may be raised by the ingestion of iodine. The organic iodine of the blood however is usually not increased by the consumption of food or iodine. In long standing hyperthyroidism the thyroid may be depleted of iodine and the blood iodine level may fall to normal or even subnormal. In borderline cases an elevated blood iodine may be of assistance in making a definite diagnosis. A person who has not taken iodine and who possesses a hyperplastic thyroid gland will not have an elevation of blood iodine as the normal person does after the administration of a certain quantity of iodine. This procedure which is known as the iodine tolerance test is not a practical routine clinical procedure and thus is not applicable to the problem at hand.

Blood Cholesterol—The blood cholesterol is decreased in active hyperthyroidism the normal range being around 180 mg per hundred cubic centimeters. In hyperthyroidism the average is usually around 140 mg. Except in a few instances we have not used blood cholesterol as a diagnostic aid in hyperthyroidism because of variations in normals. For example a cholesterol well above 200 mg in a borderline case would suggest the absence of hyperthyroidism. Its value has been chiefly in myxedema in which it is elevated out of proportion to the usual lowering of the metabolic rate.

Glucose and Galactose Tolerance Tests—Some value may be derived from performing these tests. The average patient with hyperthyroidism may show slightly increased glucose tolerance curves and the galactose tolerance test may be positive. But as aids in the diagnosis of borderline cases they are probably not worth the time and expense involved. We have therefore not used them as routine procedures.

DIAGNOSIS

In the final analysis of a questionable case of hyperthyroidism we have found it desirable to record the symptoms for and against hyperthyroidism. For example the evidence might be tabulated as follows

For hyperthyroidism

Tremor

Tachycardia

Slightly elevated metabolic rate

Weight loss

Against hyperthyroidism

Absent eye signs

Soft colloid type of gland

Absence of increased pulse pressure

Cold hands and feet

Poor appetite

No change in catamenia

Other manifestations of chronic anxiety

Such a summary would justify the diagnosis of no thyroid disease and suggests at once neurocirculatory asthenia. It is also a valuable record for future comparisons and displays at a glance how the physician evaluated the patient at the time of examination.

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THE POSITION OF THE TRACHEA BEFORE AND AFTER REMOVAL OF SUBSTERNAL GOITER

RICHARD B CATTELL and HUGH F HARE

ASYMMETRICAL and nodular goiters frequently cause displacement and compression of the trachea. In addition they may cause displacement and rotation of the larynx. The dyspnea and choking sensations brought about by the pressure of these tumors on the trachea are frequently the presenting symptoms. We have found it important to determine preoperatively the degree of displacement and compression of the trachea in order to approach operation with the more complete data that may be thus obtained. Roentgenograms of the trachea enable us to determine preoperatively the size and anatomic position of the goiter whether it is retrotracheal, retrolaryngeal, bilateral, completely intrathoracic or extends deeply sub-sternally. At the Lahey Clinic roentgenograms of the trachea are made routinely before operation in all cases of nodular, abnormally firm or irregular goiters. For this study postoperative roentgenograms were also made to determine what changes had taken place in the position of the trachea and in the adjacent soft tissues following removal.

Various types and degrees of tracheal displacement and compression have been previously reported. In this paper we wish to present (1) the position both before and after thyroidectomy and (2) the technic which in our experience best demonstrates the tracheal and surrounding soft tissue shadows.

In order best to demonstrate the position of the trachea, films taken centered over the trachea in the anteroposterior position and in either the left or right antero-oblique position are necessary, preferably with the patient in the upright position. The anteroposterior view is taken with the trunk straight, the chin up and in the median line.

The technical factors for the anteroposterior position (Fig 701 a) are as follows: a Potter-Bucky diaphragm is employed

distance 28 inches kilovoltage 80 to 88 milliamperes 100 and time three fourths second. The technical factors for the oblique view are kept constant with the exception that the kilovoltage is raised 5 to 10 k V P according to the thickness of the thorax.

The oblique view is taken with the patient leaning directly against the plate holder with the left or right chest against the holder (depending upon which side the tumor is located) at an angle of approximately 45 degrees (Fig 201 *b*). The trachea is revealed clearly by this technic as well as the outline of the soft tissue parts and to some extent the osseous condition but

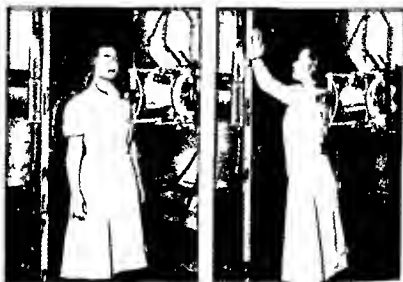


Fig 201—*a* Anteroposterior position Pott's Bucky diaphragm distance 8 inches milliamperes 100 kilovoltage 80 to 88 time three fourths second
b Oblique position Pott's Bucky diaphragm distance 28 inches milliamperes 100 kilovoltage 85 to 90 time three fourths second

the detail is not sufficiently well defined to warrant a diagnosis of bony lesions. Routine anteroposterior and oblique views of the chest taken to show pulmonary disease do not demonstrate the trachea or surrounding soft tissues well enough to be of diagnostic value especially when the tumor is small and compression or displacement slight.

Several conditions may produce shadows in the roentgenogram which are similar to and many times cannot be differentiated from tumors of thyroid origin without the clinical history and physical examination. They are (1) the apical tumor of

Pancoast, (2) metastatic carcinoma of the spine with swelling of the soft tissue anterior to the spine (3) mediastinal tumors (4) mediastinal abscess and (5) lymphoblastoma

It is unfortunate that the roentgenographic findings do not enable us to differentiate benign adenomatous goiter and malignant thyroid disease or thyroiditis but erosion of bone and visible involvement of the cartilaginous rings of the trachea are infrequent and unless there are secondary lesions showing metastasis in the bone a differential diagnosis is not possible

In the ensuing case reports examples of the various anatomic types of thyroid growths are presented. The findings common to all are that the mass appears sharply and distinctly circumscribed and the degree of compression and displacement depends upon the size and location of the growth. Frequently thyroid adenomas show irregular calcification. The retrotracheal type which occurs not infrequently displaces the trachea forward and may extend from the larynx down to the arch of the aorta. This type usually causes a marked narrowing in the anteroposterior dimension of the trachea which is best shown in the oblique view. The narrowing is usually most marked where the trachea passes beneath the manubrium although the major portion of the mass may be above or below this level. The retro-laryngeal extensions displace the voice box forward and this displacement is visible only in the oblique view. The completely intrathoracic adenomas and those which are deeply intrathoracic cause compression and displacement according to their size. Since they are situated in the anterior portion of the chest they cause little or no displacement of other tissues in the superior mediastinum. This aids in making a differential diagnosis between these tumors and others which are likely to occur in this region. Both the anteroposterior and the oblique views are necessary for diagnosing these lesions.

The postoperative films as one would expect show that the trachea returns to its normal position and there is no variation from the normal in the appearance of the surrounding soft tissue shadow.

The roentgenogram may demonstrate clearly the various types of substernal goiters whether they are retrotracheal retro-laryngeal completely intrathoracic or extend deeply subster-nally.

REPORT OF CASES

CASE 1—A woman 57 years of age who was born in Italy and lived there for thirty seven years came to the Clinic on December 9 1927. She complained of shortness of breath choking heart trouble and goiter. The goiter had appeared ten years previously and had gradually increased in size. Five years before examination she noticed that the veins on the front of her neck were prominent. There was no change in weight. She had occasional spells consisting of a choking sensation and loss of breath.

On examination it was found that respiration was noisy and marked stridor was present. Breath sounds were increased most



Fig. 1—*a* Large substernal partially calcified mass on left side of trachea compressing and displacing the trachea to the right. *b* After operation tracheal displacement persists but compression and narrowing are no longer present.

marked over the right chest. The blood pressure on the right arm was 115 mm. systolic and 65 mm. diastolic and on the left arm was 120 mm. systolic and 70 mm. diastolic. The basal metabolic rate was +17.

A roentgenogram of the trachea revealed the following: On the left side of the neck there was a large soft tissue mass extending from the midcervical region down below the arch of the aorta to the sixth rib posteriorly displacing the trachea to the right and narrowing it mediolaterally. In the oblique view the mass was partially substernal displacing the trachea anteriorly and compressing it anteroposteriorly. The mass was partially calcified and the lower

border was distinctly shown in the oblique view. The roentgenologist's opinion was large partially substernal tumor in the left side of the neck causing tracheal displacement and compression (Fig 202 a).

A diagnosis was made of adenomatous goiter without hyperthyroidism and without organic heart disease. The goiter was substernal on the left side, the huge nodular gland being palpable on both sides of the neck. The jugular veins were particularly prominent on the right side and there were dilated veins over the right thoracic wall.

At operation December 14, 1927, a subtotal thyroidectomy was done at which time the left lobe was found to extend down to the arch of the aorta. There was no substernal extension on the right side although this lobe was about three times normal size. A large cigaret drain was brought out from the left substernal space.

The patient returned for further examination on March 8, 1931, at which time the remnants of the thyroid felt normal and the larynx and trachea were in the midline of the neck. She was in excellent health. A roentgenogram of the trachea taken at this time nearly four years postoperatively confirmed the clinical examination (Fig 202 b). The trachea was normal in size throughout its course and without compression but it remained displaced to the right in its course below the clavicle. The previous anteroposterior displacement noted was not present apparently the retrotracheal portion of the mass had been removed.

CASE II—A woman 54 years of age was first examined on June 17, 1931. She had had a symptomless goiter for ten or fifteen years. For three years she had noticed dyspnea on exertion, palpitation and for one year increased difficulty in speech. She had lost 10 pounds in the past year in spite of a good appetite.

On examination at the Clinic the patient was found to have a large nodular goiter which extended well below the clavicle on the left side but a more obviously enlarged right lobe was palpable which appeared to be considerably larger than the left lobe. The resting pulse was 110, the rhythm was irregular and her blood pressure was 195 mm systolic and 75 mm diastolic. She weighed 168 pounds. A diagnosis was made of adenomatous goiter, intrathoracic on the left side with secondary hyperthyroidism. Her basal metabolic rate before operation was +45. A roentgenogram of the cervical region revealed a large partially substernal tumor in the left side of the neck extending down to the aorta displacing the trachea to the right but causing very little compression in the mediolateral diameter (Fig 203 a). In the oblique view the mass extended retrotracheally down to the arch of the aorta displacing the trachea

anteriorly and compressing the lumen to about half its normal width anteroposteriorly

On June 30 1931 subtotal thyroidectomy was done. More than two thirds of the left lobe was found within the thorax. On the right side an enlarged nodular lobe approximately 7 cm in diameter was removed leaving a moderate sized remnant. The patient made a good postoperative recovery with complete relief of her symptoms of hyperthyroidism.

Roentgenologic examination of the cervical region on December 29 1931 revealed that the trachea was in a normal position with no evidence of compression or displacement (Fig. 203 b). At the time



Fig. 203 — Not displaced and slight compression of the trachea to the right by a mass in the left side of the neck. b) Note return of trachea to normal position after operation.

of her last examination September 25 1932 the basal metabolic rate was $+3$ and her weight 177 pounds.

CASE III — A man 55 years of age came to the Clinic on May 14 1929 for a swelling of the neck of thirty six years duration. The swelling had increased gradually in size. Ten years previously it was only one third of its present size. During the past four years it had grown more rapidly and for two years it had caused great difficulty in breathing particularly on exertion.

On examination the patient was found to have a large adenomatous goiter with secondary hyperthyroidism. The basal metabolic rate before operation was $+37$ and the weight 170 pounds. The

blood pressure was 170 mm systolic and 100 mm diastolic. A preoperative tracheal roentgenogram (Fig 204 *a*) revealed a large tumor on both sides of the trachea, on the right extending sub sternally down to the arch of the aorta displacing and compressing the trachea to the left and compressing it in all diameters so that the lumen was approximately only one fourth its normal size.

On May 31 1929 right first stage hemithyroidectomy was carried out. A large adenomatous gland was found which extended below the arch of the aorta on the right side. It was necessary to enucleate practically the entire right lobe.

Prior to the second operation which was done on July 29 1929 the basal metabolic rate was -2 . Left subtotal hemithyroidectomy



Fig 204—*a* Large partially substernal tumor on right side of neck displacing and compressing the trachea to the left. *b* After operation showing displacement to the right apparently due to an adenomatous left lobe of the thyroid.

was done at this time on a nodular gland three times normal size. Only half of this lobe was removed. It did not extend below the clavicle.

On December 17 1930 the metabolic rate was -11 , weight 200 pounds and blood pressure 100 mm systolic and 90 mm diastolic.

On March 11 1931 the patient returned for reexamination. At this time clinical examination revealed that the trachea which formerly was on the left side now deviated to the right. An adenomatous left lobe of the thyroid gland, approximately 7.5 by 5.5 cm, could be palpated, which accounted for the position of the trachea (Fig 204 *b*). There were no symptoms of hyperthyroidism. It was thought that this was hypertrophy of the small amount of thyroid

tissue remaining. A roentgenogram of the cervical region revealed a partially substernal tumor on the left side of the neck displacing and compressing the trachea to the right. During routine examination a mass was discovered in the rectum. Exploratory laparotomy revealed an inoperable carcinoma of the rectum. The patient died on April 15, 1913.

CASE IV—A woman 35 years of age first came to the Clinic on March 11, 1930, complaining of goiter of twelve years' duration and of recent attacks of a choking sensation. There had been a gradual increase in the size of her neck with a recent noticeable enlargement. During recent respiratory infection a choking sensa-



FIG. 20.—a Large substernal tumor on right side of the neck extending to the arch of the aorta displacing and compressing the trachea to the left below the clavicle. b Note normal position of trachea following operation.

tion developed and at one time the patient was awakened from sleep by a coughing spell associated with difficulty in breathing. She had taken Lugol's solution for a few days before examination.

The pulse rate at her first examination was 180; the rhythm was irregular and the blood pressure was 195 mm. systolic and 75 mm. diastolic. An adenomatous goiter with secondary hyperthyroidism was found. The right lobe was markedly enlarged and extended down into the chest. The left lobe was enlarged to about 6 cm. in diameter but it was not substernal. A roentgenogram of the trachea (Fig. 20, a) showed a large substernal tumor on the right side of the neck extending down to the arch of the aorta, displacing and compressing the trachea to the left below the clavicle. The mass

lay anterior to the trachea and compressed it slightly antero posteriorly. On the left side of the neck there was a large partially calcified mass which displaced the trachea to the right above the clavicle but did not extend substernally. The roentgenologist reported a partially substernal tumor on the right side and a large tumor on the left side of the neck which displaced the trachea to the right.

The basal metabolic rate before operation was +46 and the weight 107 pounds. The blood pressure was 210 mm systolic and 90 mm diastolic. On March 24, 1930, left subtotal hemithyroidectomy first stage was done as the tumor was smaller on this side and the patient was considered to be a poor surgical risk.

On May 19, 1930, right subtotal hemithyroidectomy second stage was performed. A very large intrathoracic goiter was removed from the right side, exposing an area of pleura and the outline of the arch of the aorta.

At the time of her last examination on May 27, 1931, the metabolic rate was -4, weight 127 pounds, and blood pressure 140 mm systolic and 90 mm diastolic. A roentgenogram taken on March 18, 1931, showed the trachea to be in its normal position without evidence of compression or displacement (Fig 205 *b*). There was an increase in paratracheal soft tissue shadows on the right.

At this time the patient was in excellent general health. There was no alteration of voice. The thyroid scar was caught up at the site of the drain on the right side of the neck. An indirect laryngeal examination showed that the action of the vocal cords was normal.

CASE V—A woman 48 years of age had noticed a goiter for at least thirty years. It had varied little in size and had caused no symptoms until a short time before examination in June, 1931. She had taken thyroid extract at intervals during 1929 and 1930 and had lost 14 pounds in the last few months.

On examination a large firm adenoma of the left lobe was found which displaced the larynx to the right and the trachea posteriorly. With the patient at rest her pulse rate was 128 and her blood pressure was 190 mm systolic and 80 mm diastolic. The basal metabolic rate before operation was +50 and she weighed 147 pounds.

A roentgenogram of the trachea (Fig 206 *a*) revealed a large partially calcified mass on the right side of the neck, displacing and compressing the trachea to the left. The mass extended only slightly substernally. On the left side there was a small calcified mass partially covered by the clavicle but situated just to the left of the trachea, causing no compression or displacement of the trachea.

On June 18, 1931, subtotal thyroidectomy was done. A large

goiter 10 cm in length was found which passed deeply into the right chest. The right lobe appeared to be made up of a single discrete adenoma which was calcified and adherent. On the left side there was a calcified nodule and a nodular gland about three times normal size.

A roentgenogram of the trachea (Fig 206 *b*) taken on September 24 1931 showed no evidence of compression or displacement and there was no abnormal soft tissue mass visible in the neck. At the time of the patient's last examination October 21 1936 the



Fig 206—*a* Trachea is displaced to the left by a large partially calcified mass on the right side of the neck. *b* After operation, the return of trachea to its normal position and contour.

metabolic rate was -8 , the weight was 191 pounds and the blood pressure was 140 mm systolic and 85 mm diastolic.

CASE VI—A man 43 years of age first came to the Clinic on March 19 1931. He had had a small swelling of the left side of his neck for about two years. It had not caused symptoms until January 1931 when an upper respiratory infection developed. The swelling then increased rapidly for two or three days before examination.

Examination of the thyroid gland revealed a large adenoma of the left lobe approximately 15 cm in diameter displacing the trachea and the larynx markedly to the right. A small adenoma 2 cm in diameter could be palpated in the right lobe. A diagnosis was made of adenoma with recent hemorrhage. The basal metabolic rate was normal.

A roentgenogram of the trachea (Fig 207 *a*) taken preoperatively showed a large soft tissue mass on the left side of the neck which

did not extend substernally but displaced the larynx and trachea far to the right causing only slight narrowing of the trachea.

At operation March 25 1931 the large adenoma was enucleated from the left lobe. The lesion was fluctuant and was adherent to the overlying sternohyoid muscle. A small adenoma was removed from the right lobe.

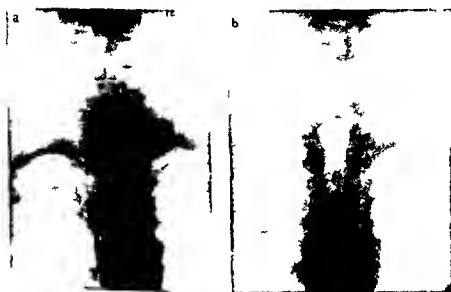


Fig 201—*a* Large soft mass on left side of neck displacing trachea and larynx to the right. The trachea is only slightly narrowed. *b* After operation note return of trachea to normal position.

Examination August 6 1931 showed that the larynx was in the midline. The thyroid remnants were normal (Fig 207 *b*).

CASE VII—A woman 43 years of age was first examined at the Clinic on June 18 1931. She had had a swelling in her neck for eight years which had gradually increased in size. There were no pressure symptoms except during frequent attacks of laryngitis.

On examination a discrete adenoma of the left lobe of the thyroid gland 9 cm in diameter was found. The right lobe was normal. A roentgenogram of the cervical region (Fig 208 *a*) revealed a large soft tissue mass in the left side of the neck extending slightly substernally and retrotracheally displacing the trachea to the right and anteriorly and narrowing it in all diameters; the lumen of the trachea was about one fourth its normal size. The basal metabolic rate was normal.

On June 20 1931 a large degenerated cystic adenoma was excised. The right lobe was normal.

On October 8 1931 examination revealed no abnormality of the neck except the well healed thyroid scar. A roentgenogram of the

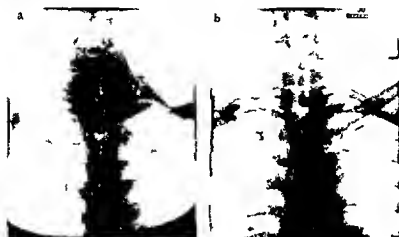


Fig 208—*a* Large soft tissue mass in left side of neck extending slightly substernally and retrotracheally and displacing the trachea to the right and anteriorly. *b* After operation trachea is in its normal position without evidence of compression.

trachea showed it to be in its normal position without evidence of compression (Fig 208 *b*).

THE DIAGNOSIS AND PROGNOSIS OF BRAIN TUMORS*

GILBERT HORRAX

THE surgery of brain tumors has made many and notable advances during the last decade and with these advances has come more exact knowledge of what may be accomplished by operative measures. For this reason it is more important than ever to reiterate certain features regarding the diagnosis of these lesions and to discuss what results may be expected from their removal.

In considering the diagnosis of brain tumor two features must be kept constantly in mind. First has the patient a brain tumor or some other type of intracranial lesion which simulates tumor and secondly if a tumor is present what is its situation and its pathology? With our present neurologic knowledge and diagnostic methods, the first of these questions can be answered in practically every case provided the patient or the responsible relatives consent to thorough diagnostic measures. With regard to the second question we are likewise usually able to locate the tumor exactly but its pathology predictable in a large and ever increasing percentage of cases often cannot be determined prior to operation.

DIAGNOSIS AND DIFFERENTIAL DIAGNOSIS

From the standpoint of diagnosis there are roughly two clinical types of brain tumor (1) that which presents the well known symptoms and signs of brain tumor and (2) that which presents many different neurologic or other findings but lacks the usual textbook picture.

1 Tumors with Typical Symptoms

With regard to the first type when the complaints include headache and vomiting and the ophthalmoscope shows choking of the optic disks the burden of proof is obviously on the per

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son who says that the diagnosis is not brain tumor. Nevertheless there are certain other conditions which may produce this time honored triad and from which tumor must be differentiated. Among these are *brain abscess* which may be suspected from a preceding infectious process particularly an old otitis media chronic mastoiditis frontal sinusitis scalp infection or bronchiectasis to mention a few of the common possibilities. Another condition which is recognized as a clinical entity is the so called increased intracranial pressure without tumor that is *pseudotumor* or *arachnoiditis* which may be surmised when pressure symptoms together with choked disks are acute and the neurologic signs absolutely lacking. Often this little understood possibly inflammatory disturbance seems to be almost epidemic in character. The diagnosis can be made with certainty only by a ventriculogram which shows normal sized ventricles in normal position. These patients almost universally may be cured permanently by a simple decompression.

Malignant hypertension may also cause headache and choked disks. As a rule the diagnosis can be made on the basis of the blood pressure findings together with evidence of cardiorenal disease but when the systolic and diastolic pressures are only moderately elevated an air study may be indicated to rule certain that a growth is not overlooked. A *chronic subdural hematoma* may simulate tumor almost exactly but the bilateral trephine holes used in carrying out the ordinary ventriculogram and situated over each parieto occipital region will almost inevitably disclose a unilateral or bilateral hematoma and thus confirm the diagnosis before the air study is performed. From the purely neurologic aspect a differential diagnosis between a chronic subdural hematoma and a tumor is seldom possible. A history of slight or moderate head trauma and the subsequent development of increasingly severe headache is suggestive. The headache caused by subdural hematoma is sometimes excruciating and more incapacitating than that caused by most tumors—it would perhaps better be called severe intracranial pain rather than headache. Another prominent feature of chronic subdural hematoma is the bizarre mental changes but almost any or all combinations of neurologic signs may be present. *Meningococcal lues* and *tuberculous meningitis* should also be mentioned as conditions sometimes mistaken for brain tumor but as a rule

there is little difficulty in differentiating them by means of spinal fluid studies

Lumbar Puncture in Probable Brain Tumor—Caution!—In speaking of spinal fluid findings a word of caution should be extended concerning the use of lumbar puncture as a diagnostic measure in probable brain tumor. It is seldom necessary for making such a diagnosis and except in rare instances adds nothing which cannot be learned more safely by means of careful neurologic study together with a ventriculogram when indicated. In trained hands and with due caution accidents are rare but the danger is not purely theoretical avoidable deaths having occurred in practically all large neurologic and neurosurgical clinics where this measure is undertaken routinely. If a lumbar puncture seems advisable a careful manometric reading should be made before any fluid is withdrawn. If the pressure is above 200 mm. of water with the patient entirely relaxed only 2 or 3 cc. of fluid should be taken that is sufficient for a cell count and total protein determination. If the pressure is extremely high that is over 300 mm. it would be wiser to take no fluid at all but rather to have neurosurgical consultation and if necessary a ventriculogram.

2 Tumors with Atypical Symptoms

Under the second category of patients that is those who do not have choked disks and other usual manifestations of brain tumor a variety of neurologic ophthalmologic and otologic evidence may have led to the suspicion of tumor and for this reason the patients must be studied with such a lesion in mind. Among these symptoms I would mention particularly focal or generalized convulsions especially in adults slow visual failure with some degree of unexplained optic atrophy changes of personality in the absence of cerebral arteriosclerosis or evidence of some clear cut recognizable psychosis increasing unilateral deafness staggering or a slowly progressive hemiparesis which at first was thought to be due to cerebral thrombosis.

In patients with these symptoms and signs the diagnosis may be difficult and entail elaborate study. A careful chronologic history together with a neurologic examination are the first requisites but in addition roentgenologic examinations of the skull visual field examinations with small test objects color tests

electro encephalogram and either an air encephalogram or ventriculogram may all be necessary. At times a careful lumbar puncture may give useful information. As a rule the differential possibilities are such conditions as epilepsies of various etiology not due to tumor, cerebrovascular disease, multiple sclerosis, labyrinthitis, posttraumatic headache and dizziness, platybasia and occasionally primary anemia or psychoses of different sorts.

The various kinds of *convulsions* usually can be suspected from the history, neurologic examination, blood tests or evidence of an irritable carotid sinus, but often an air encephalogram must be made as a final determination. The same is true in the differentiation from *cerebrovascular disease* in which the encephalogram shows symmetrical but usually somewhat enlarged ventricles and wide subarachnoid spaces indicating some degree of cerebral arteriosclerosis. *Multiple sclerosis* may be surmised when there is nystagmus with some degree of ataxia, increased deep reflexes and absent abdominal reflexes. It must be remembered, however, that occasionally tumors just at the level of the foramen magnum may give these signs also, hence the value of a lumbar puncture and perhaps an encephalogram. Indeed, I have seen a prompt remission of symptoms in a patient with multiple sclerosis directly after the performance of air encephalography. *Platybasia*, a bony abnormality in which the odontoid process of the axis is shown by roentgenogram to be at a considerably higher level than normal, may give symptoms of multiple sclerosis or a posterior fossa lesion. The condition may be helped by suboccipital decompression.

SITUATION AND PATHOLOGY

With regard to the situation and pathology of brain tumor, it is now well known that the brain harbors a large variety of tumors, but what is not so well known is the fact that the life histories and the clinical syndromes characteristic of certain types of growths in certain situations have been worked out in elaborate detail in the course of the last twenty-five years. The late Harvey Cushing and his associates were responsible for much of this information.

For the purposes of this part of our study, we may again divide brain tumors into two groups so far as the diagnosis of their situation and pathology is concerned. In the first group

are those tumors which as a rule can be recognized with a high degree of accuracy from the symptoms and objective neurologic or other clinical signs which they produce and in the second those which give no characteristic evidence of their whereabouts

I Tumors Recognizable from Symptoms and Clinical Signs

In a general way but by no means without exception the first group includes largely those tumors which are benign encapsulated and favorable for complete enucleation that is certain of the meningiomas the acoustic neuromas the pituitary adenomas and some benign but uncommon tumors such as cholesteatomas or slowly growing gliomas which give characteristic roentgenologic findings. Also in this category are the somewhat less favorable tumors such as the congenital cysts of Rathke's pouch pinealomas and some intracranial aneurysms which should be classed as tumors. In this short discussion only the briefest possible mention can be made of the diagnostic features of these tumors

Meningiomas—Meningiomas are the well known firm encapsulated growths which are attached to the dura and occur in various favorite situations. Those under the frontal lobes give slow mental changes loss of the olfactory sense and often optic nerve atrophy on one side and papilledema on the other the syndrome of Foster Kennedy. The small meningiomas situated just above the sella turcica cause gradual failure of vision optic nerve atrophy and bitemporal defects of the visual fields. They are differentiated from pituitary adenomas because the sella is not enlarged and pituitary functions are not lost. Meningiomas arising from the greater wing of the sphenoid often cause great hypertrophy of the bone in this area by tumor cells infiltrating the bone and the eye on the affected side is pushed forward to a considerable degree (unilateral exophthalmos). Occasionally meningiomas of the cranial vault may cause marked hyperostosis of the region involved. Other meningiomas at various places over the cerebral convexities frequently cause characteristic bony enostoses and an increase in vascularity of the skull which is shown by the roentgenogram.

Practically all meningiomas are capable of complete extirpation and except in very rare instances nothing short of total

removal should be contemplated. This may entail a prolonged tiresome delicate and at times extremely difficult operation. Vascularity is often excessive and in the more serious procedures one or more transfusions are the rule. Occasionally more than one operative session is required before the tumor can be wholly taken out and sometimes a considerable portion of the longitudinal sinus where it has been invaded by growth must be removed. The results however fully justify the efforts and nearly all patients can be returned to active life. One of the chief postoperative disabilities is the continuation of convulsions even though the tumor has been wholly eradicated but these tend to lessen in frequency and severity and of course can be controlled fairly well by medication.

Acoustic Tumors—The syndrome of acoustic tumors which are the common cerebellopontile angle growths is now well known. A careful chronologic history usually starts with unilateral tinnitus followed by increasing deafness in that ear and then numbness on the same side of the face staggering headache and finally failing vision dysarthria and dysphasia if the tumor is not recognized and removed. Objectively there is slow nystagmus hypoesthesia of the face on the affected side staggering gait positive Romberg ataxia and an absent caloric response from the affected ear. The optic disks may show choking. An appropriate roentgenologic examination of the skull often will show erosion of the internal auditory meatus on the side of the lesion.

Acoustic neuromas like meningiomas should be completely removed because if the old type of intracapsular—and therefore incomplete—extirpation is performed recurrence at some future time is inevitable and secondary operations for recurrence carry a high mortality. Occasionally there may be a five year ten year or even a longer interval between incomplete removal and recurrence but the longer periods are rare. Many patients show evidence of further tumor growth in less than five years. The chief objection to complete removal of an acoustic tumor is the almost certain facial paralysis which is usually inevitable. This however can be partially remedied by a spinofacial anastomosis and almost without exception patients prefer complete eradication of the tumor rather than face a recurrence. This matter is always talked over with the patient prior to operation.

Adenomas of the Pituitary Gland—Adenomas of the pituitary gland present little diagnostic difficulty. The familiar triad of optic atrophy, bitemporal hemianopsia and a greatly enlarged sella turcica as shown in the roentgenogram can hardly be mistaken, especially when there are the usual evidences of pituitary dysfunction such as amenorrhea in the female, loss of libido and feminine distribution of body hair in the male, a lowered basal metabolic rate and increased carbohydrate tolerance. If the adenoma is of the chromophile type the resultant clinical picture is that of acromegaly. Occasionally an aneurysm in this situation may give signs which are extremely similar.

Most chromophobe pituitary adenomas require surgical extirpation unless they are in an early stage with only slight visual loss in which case a trial of roentgen therapy is in order. In the operable stage the mortality is low (5 per cent or less) and the return of visual function is usually prompt and satisfactory. When however patients have been allowed to procrastinate too long, perhaps with slight help from radiation, the adenoma is apt to spread out under the frontal or temporal lobes to such a degree that operation becomes difficult and dangerous and roentgen therapy has long since ceased to be beneficial.

Unusual Tumors—Of the more unusual tumors whose site and character often may be recognized by the roentgenogram, *diploetic cholesteatomas* show a scalloped outline of bony excavation. *Cranio-pharyngiomas* or *Rathke's pouch cysts* cause deformation of the sella often with calcification above it and either choked disks or optic atrophy according to whether they protrude posteriorly or anteriorly to the chiasm. Certain calcified gliomas, notably the *oligodendrogliomas*, are likely to have a characteristic roentgenogram and the same is true of some *intracranial aneurysms*. The latter are diagnosed with certainty by the injection of thorotrast into the internal carotid in the neck on the affected side. *Pinealomas* are rather rare tumors but may be recognized with fair accuracy from the neurologic features of pupillary inactivity to light and loss of conjugate movements of the eyeballs upward above the horizontal plane. Usually this diagnosis must be confirmed by ventriculogram which shows a rounded shadow bulging into the posterior portion of the third ventricle.

2 Tumors Giving Inconclusive Evidence of Their Situation

The tumors in the second group seldom or never give any neurologic or other evidence of their situation hence this must be determined by means of air ventriculography. This group includes many of the large infiltrating *gliomas* of all kinds occupying the so called silent areas of the brain. Indeed the diagnosis of a considerable number of cerebellar tumors both benign and malignant can be made with certainty only by resorting to air studies since cerebellar symptomatology may be inconclusive. In addition to the *gliomas* both above and below the tentorium *meningiomas* which do not show roentgenologic changes or a characteristic clinical syndrome will likewise require air studies. Other tumors in this second group are those in the region of the third ventricle a good many of the metastatic growths and certain of the more rare lesions which need no enumeration. Many tumors in this group are extremely favorable such as *gliomatous* and *hemangiomatous cysts* both above and below the tentorium. The latter are perhaps the most satisfactory of all brain tumors as patients do not develop convulsions after their removal.

PROGNOSIS

Needless to say the outlook for permanent useful life in a patient harboring a brain tumor is dependent upon complete removal of the tumor without damage to important neighboring structures. Recurrence is inevitable unless the growth is entirely removed. Although some tumors grow very slowly and partial removal may give several years of freedom from symptoms nevertheless our aim should be total extirpation of all benign growths except under extremely rare circumstances. Fortunately with modern equipment including electrosurgery, strong suction apparatus and a well organized neurosurgical team this is now possible in a high percentage of cases. Even in the infiltrating tumors if a radical subtotal extirpation is done and I personally believe it should be many patients will have surprisingly long periods of normal and useful life—occasionally five or even ten years if a slowly growing *glioma* is encountered.

The use of *roentgen therapy* for malignant brain tumors with the exception of *medulloblastomas*, *pinealomas* and occa-

sionally oligodendrogliomas has been completely disappointing in my experience and any favorable results after such roentgen therapy could just as well have been due either to the tumor removal or to the decompression which may have been left at the time of operation. As mentioned previously roentgen therapy deserves a trial in cases of early pituitary adenoma since a certain number of these tumors are radiosensitive but it is tragic to see not infrequently patients who have become blind because this treatment was persisted in until the optic nerves became completely atrophied when an earlier operation might have restored nearly normal vision.

Survival Rates after Extirpation

Concerning prognosis we can now be infinitely more specific than in the earlier years of neurosurgery when all brain tumors were regarded as relatively hopeless lesions and the occasional long survival of a patient from whom a tumor had been removed was regarded as an interesting and rare surgical curiosity. The largest and most exhaustively studied series of verified brain tumors is that of Cushing and in 1935 Eisenhardt¹ reported the end results in these cases listing those in which the patient had survived five years or longer. There were 2 000 patients in the series and of these about 1 600 survived the operation and the subsequent period of hospitalization. Of this number about 31 per cent or nearly one third had since operation lived from five to twenty eight years up to the time the report was made seven years ago. Obviously many more would now be included in this survival list if the figures were brought up to date.

Useful Life After Extirpation

These statistics did not include a discussion of useful life but at least they are most enlightening from the standpoint of actual survival especially since this series includes all varieties of tumor both benign and malignant and dates from the very beginning of neurosurgery in this country. Consequently if only the last ten or fifteen years had been reviewed the results would unquestionably have been even more striking.

But mere survival regardless of the physical and mental status of the individual is not or should not be our true aim. Therefore in an attempt to gain some idea about useful survival of patients with brain tumor that is patients who after operation

either went back to their original occupation or to some useful type of work. I have reviewed my own series of verified brain tumors from 1933 to 1939 which consisted of some 400 cases.³ This gives a follow up period of from three to nine years. It was apparent as would be expected that those patients who had done best were in the group with benign or favorable tumors that is those from whom the tumor could or should have been completely removed and it was this group only that was studied with respect to useful survival. Well over one half of all my tumor patients fell into this favorable category and although the tumors of many others were partially extirpated and the patients had useful survival periods they were not included in this group.

The favorable tumors consisted mostly of meningiomas, acoustic neuromas, pituitary adenomas, gliomatous and hemangiomatous cysts of the cerebellum and a rather large group of uncommon tumors the names of which are not pertinent here. All told this favorable group comprised 218 of the 400 tumors or 54.5 per cent. The operative mortality was 1.3 per cent (27 patients) and 16 other patients had died at various times subsequently. Of the survivors 27 have severe disabilities which prevent them from engaging in useful occupations leaving 148 patients or 67.8 per cent of the original 218 who are living and actively engaged in some form of work. If one takes the percentage only of the 191 who survived the operation the figure of useful life rises to 77.6 per cent.

In general terms therefore somewhat over half of all brain tumors are favorable for complete extirpation and of those patients who survive operation about three fourths ought to be returned to useful life. As stated before this figure does not include a fair number of patients who have tumors which can not be eradicated completely and yet who may have several years of useful existence after their tumors have been radically but subtotally removed.

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BRAIN TUMORS IN THE PRESENCE OF NORMAL AIR STUDIES

JAMES L. POPPEN and WILLIAM G. PEACHER

It is a generally accepted fact that in the vast majority of cases the presence of a brain tumor can be disclosed by encephalographic or ventriculographic studies. The importance of such studies cannot be overemphasized; however, we have had 10 cases of tumor without changes in the ventricular system in which focal epilepsy was the outstanding symptom in all but 3 cases. Focal convulsions are often caused by a tumor involving the Rolandic area of the brain. A tumor usually is accompanied by further signs of localization as well as ventricular deformity. Certainly one hesitates to carry out an exploratory craniotomy in a patient with focal seizures when neurologic studies including air studies are normal unless the patient is completely disabled because of the frequency and severity of attacks. Therefore before surgery or any other form of treatment is undertaken certain criteria should be considered. These include age, duration of symptoms, occupation, frequency and intensity of attacks and the hemisphere presumably involved as well as the reaction of the patient to anticonvulsive therapy if previously instituted. Electroencephalograms should always be taken before air studies are made since localized abnormal brain waves corresponding to the symptoms would naturally make one more inclined to explore the affected region even in the presence of normal air studies.

Age is important since patients developing convulsions after 30 should be considered brain tumor suspects provided no obvious general systemic condition is present capable of producing convulsions. The duration and intensity of symptoms, previous treatment and its effect may influence one in deciding upon the course of treatment. The hemisphere involved deserves consideration. One would be less eager to explore the left hemi-

isphere in a right handed individual than the right hemisphere because of possible speech difficulties that could result from surgery Finally the occupation of the patient might alter one's opinion as to the treatment

Regardless of age duration and intensity of symptoms occupation hemisphere involved or efficacy of previous treatment an orderly investigation should be carried out in all patients who have focal seizures before surgery is undertaken This investigation should include a thorough general physical and neurologic examination blood and urine examinations stereoscopic x rays of the skull electroencephalography and oxygen encephalography

If these studies are within normal limits the considerations already mentioned thoroughly weighed and the patient or his family informed that the negative results do not necessarily rule out brain tumor conservative measures with anticonvulsive drugs are justified Conservative treatment may be continued as long as it is effective in keeping the attacks under control and no progressive neurologic changes occur If the attacks continue exploration not only is justified but also indicated Fortunately such cases are rare however they do occur and the possibility of brain tumor must be kept in mind to avoid disaster to the patient and embarrassment to the surgeon

REPORT OF CASES

CASE I—A 19 year old girl was in the hospital from February 2 to February 29 1936 with a chief complaint of generalized convulsions of eleven years duration Her first attack occurred two weeks following scarlet fever at the age of 8 years There was no warning and the attacks were typically grand mal with exception of residual sensory aphasia for a brief period following each convulsion Pheno barbital had not given complete relief from convulsions Positive findings on examination were a mild tendency toward euphoria, slight haziness of the dist margins and hyperactive reflexes over both lower extremities An encephalogram on February 3 showed normal filling of the ventricular system however extending inward from the inner table of the left parietal region were two oval areas made up of small irregularly outlined calcium shadows (Fig 209) The findings were consistent with calcification in a hematoma or in a tumor mass On February 7 a left parietal craniotomy was performed with excision of a verified meningioma (4 by 4.5 by 5.5 cm) containing calcium deposits extending into the parietal lobe



Fig 209

Comment—The presence of calcification in the tumor in the roentgenogram plus the focal symptoms of residual sensory aphasia for an hour following a convulsion and not the encephalogram determined the site of the tumor

CASE II—A 37 year old woman was in the hospital from April 16 to May 15 1937 with a history of generalized convulsions. These were not associated with trauma or infection. The first convulsion occurred in July 1936 and was typically grand mal in character. Two additional generalized convulsions occurred on January 2 1937. Since the onset of these seizures there had also been fairly persistent left temporal headache. Roentgenologic examination of the skull on April 9 1937 was consistent with a diagnosis of a calcified brain tumor in the left frontal region. An encephalogram showed no change from the normal. A left frontotemporal craniotomy was performed on April 20 1937 at which time a meningioma (2 by 3.5 by 4 cm) was removed from the left frontotemporal region.

Comment—Here again the calcification in the tumor and not the ventricular distortion indicated the site of the lesion. The tumor had made a nest in the cortex and was not attached to the dura. It could readily be understood why no displacement in the ventricular system had taken place.

isphere in a right handed individual than the right hemisphere because of possible speech difficulties that could result from surgery. Finally, the occupation of the patient might alter one's opinion as to the treatment.

Regardless of age, duration and intensity of symptoms, occupation, hemisphere involved or efficacy of previous treatment, an orderly investigation should be carried out in all patients who have focal seizures before surgery is undertaken. This investigation should include a thorough general physical and neurologic examination, blood and urine examinations, stereoscopic x-rays of the skull, electroencephalography and oxygen encephalography.

If these studies are within normal limits, the considerations already mentioned thoroughly weighed, and the patient or his family informed that the negative results do not necessarily rule out brain tumor, conservative measures with anticonvulsive drugs are justified. Conservative treatment may be continued as long as it is effective in keeping the attacks under control and no progressive neurologic changes occur. If the attacks continue, exploration not only is justified but also indicated. Fortunately, such cases are rare, however they do occur, and the possibility of brain tumor must be kept in mind to avoid disaster to the patient and embarrassment to the surgeon.

REPORT OF CASES

CASE I—A 19 year old girl was in the hospital from February 2 to February 29, 1936, with a chief complaint of generalized convulsions of eleven years' duration. Her first attack occurred two weeks following scarlet fever at the age of 8 years. There was no warning and the attacks were typically grand mal with exception of residual sensory aphasia for a brief period following each convulsion. Pheno-barbital had not given complete relief from convulsions. Positive findings on examination were a mild tendency toward euphoria, slight haziness of the disk margins and hyperactive reflexes over both lower extremities. An encephalogram on February 3 showed normal filling of the ventricular system, however extending inward from the inner table of the left parietal region were two oval areas made up of small irregularly outlined calcium shadows (Fig. 09). The findings were consistent with calcification in a hematoma or in a tumor mass. On February 7, a left parietal craniotomy was performed with excision of a verified meningioma (4 by 4.5 by 5.5 cm.) containing calcium deposits extending into the parietal lobe.

Babinski sign on the right. Encephalograms (Fig 211) as well as other laboratory studies were negative. On dismissal on December 7 the patient's condition was unchanged.

On readmission to the hospital on February 1, 1940, the patient reported that in spite of adequate anticonvulsive treatment the seizures with loss of consciousness had continued. In addition, headache had developed over the left parietal region. The signs remained as before with the addition of spastic paralysis of the right arm. On February 7, left frontal craniotomy was performed with subtotal



Fig 211

extirpation of a fibrillary astrocytoma involving face and arm areas of the motor strip.

Comment—Exploration was certainly justifiable here in the presence of normal air studies because of the progressive changes. The tumor was invasive with little or no surrounding edema of the brain substance and had not attained sufficient size to cause ventricular deformity.

CASE V—A 13 year old boy entered the hospital on September 6, 1940, with a one year history of right sided jacksonian seizures which had become generalized and associated with brief episodes of aphasia but no loss of consciousness. They were preceded by an aura of right sided paresthesias. Petit mal attacks had also been present over a similar period of time. The neurologic examination

CASE III—A 56 year old woman was in the hospital from December 12 to December 16 1937 and again from December 19 1937 to January 16 1938. Her chief complaints were generalized headache for ten to fifteen years and diplopia and spots before the eyes for two years. The neurologic examination was entirely within normal limits. On December 14 roentgenologic examination of the skull showed an area of increased density 1.5 cm. in diameter over the right parietal region. Ventriculograms on December 20 were essentially negative (Fig. 210). On December 27 a right central osteo-



Fig. 10

plastic flap was performed with complete excision of a parasagittal meningioma (3 by 4.5 cm.) which was subsequently pathologically verified.

Comment—Here again one can visualize why a small slowly growing surface tumor had embedded itself in the cortex without distortion of the ventricular system.

CASE IV—A 31 year old man entered the hospital on November 29 1939 with a six weeks history of jacksonian seizures involving the right upper extremity without loss of consciousness. He also had had weakness of the right arm for four or five days. The neurologic examination showed right central facial weakness and marked diminution in motor strength of the right arm. The reflexes were increased in the right upper extremity and there was an equivocal

Babinski sign on the right. Encephalograms (Fig 211) as well as other laboratory studies were negative. On dismissal on December 7 the patient's condition was unchanged.

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was negative except for slight right central facial weakness. Anti-convulsive therapy had been of little value. Encephalograms made elsewhere and also by us were normal (Fig. 212) as were the other laboratory studies. Electroencephalograms showed abnormal waves from both precentral areas, slightly greater on the left. On September 14, through a left frontoparietal craniotomy, a fibrillary astro-



Fig. 212

cytoma measuring 2.5 to 3 cm. in diameter was extirpated from the arm center in the motor area.

Comment—The electroencephalograms were a distinct help in this case, however, since anticonvulsive therapy had been of little value, exploration was carried out. The small tumor replaced only a portion of a single gyrus, and although it could be identified readily by direct vision, its size was such that it could not possibly have distorted the ventricular system.

CASE VI—A 29-year-old man entered the hospital on March 18, 1942, with a three-months history of right-sided focal seizures beginning in the face. There was loss of consciousness and an aura of right-sided paresthesias. The neurologic examination showed right central facial weakness with nystagmus in all directions. Speech was slow and halting with questionable early aphasia. There was slight ataxia on the right, possibly due to weakness. The electroencephalogram showed abnormal activity over the left hemisphere.



Fig. 1b

Comment—This case was almost identical with Case VI

CASE IX—A 33 year old woman entered the hospital on November 10 1947 with a history of left sided seizures associated with an aura of paresthesias of five years duration. She did not always lose consciousness but the attacks were followed occasionally by left sided numbness. Encephalograms made elsewhere were within normal limits. The neurologic examination showed slight weakness of the left side and absent knee and ankle jerks. The electroencephalogram showed a focal cortical disturbance over the electrodes in the region of the right rolandic fissure. Because of failure to improve on the usual anticonvulsive therapy and in spite of her long history and normal encephalogram exploration was performed on November 16 through a right central craniotomy with removal of an astrocytoma involving the right frontal and parietal lobes extending into the motor area at the arm and leg centers.

CASE X—A 25 year old woman entered the hospital on November 25 1947 with a three weeks history of right sided headaches and focal seizures involving the right upper extremity. The attacks had been intermittent and two were associated with loss of consciousness. There had also been recent blurring of vision. The neurologic examination showed slight motor aphasia and mild confusion with definite weakness of the right arm. The reflexes were difficult to elicit over the upper extremities, but were slightly more active in the right lower extremities. The electroencephalogram showed a

controlled on the usual anticonvulsive therapy a craniotomy was performed on July 30 and an astrocytomatous cyst involving the leg center of the right motor area was removed.



Fig 214

Comment—The history and neurologic findings indicated the presence of a tumor even though the ventriculograms as well as encephalography were entirely within normal limits.

CASE VIII—A 56 year old woman entered the hospital on August 27 1947 with a three months history of focal seizures involving the right leg. Loss of consciousness occurred only on the first occasion. For three weeks there had been increasing weakness of the right leg. The neurologic examination showed motor weakness of the right leg most marked in the right foot. The abdominal reflexes were less on the right than on the left and there was a right Babinski sign. The encephalograms were not entirely satisfactory so a ventriculographic study was performed (Fig 215). This was negative as were the remaining laboratory studies with the exception that the total protein from the left ventricle was 101 mg. Due to the patient's failure to improve on the usual therapy a left frontoparietal craniotomy was performed on September 12. A tumor approximately 2 cm in diameter was removed from the leg area of the motor strip. Microscopic diagnosis was astrocytoma with poorly differentiated foci approaching glioblastoma.

usual palliative measures whether or not there are localizing signs and positive air studies

The reason that ventricular displacement did not take place in the 10 cases is easily understood. The brain tumors causing symptoms sufficient to warrant the advice of a neurosurgeon in the presence of negative air studies are in the order of their frequency: fibrillary astrocytomas, meningiomas (small) and blood vessel tumors. The pituitary adenomas and small aneurysms are not included for these usually have characteristic symptoms and ventricular changes.

CONCLUSIONS

These 10 cases demonstrate that visualization of the ventricular system is not always diagnostic even in the presence of tumors producing physical signs and symptoms. All cases of focal epilepsy in the absence of obvious nonsurgical etiologic factors—that is, cerebrovascular disease and so forth—and that fail to respond to the usual anticonvulsive therapy should be explored.

THE INTERPRETATION OF SYMPTOMS IN SURGICAL DISEASES OF THE CHEST

CARLTON R. SOUDERS

HISTORY

The diagnosis of surgical diseases of the chest never should be considered complete without a careful case history. While roentgenologic examination is undoubtedly the most important single diagnostic measure and physical examination may give information not obtainable by any other means, a complete chronologic recording of the course of the disease will give a picture not approximated by any other method. The patient's memory must be prompted by judicious questioning in order to elicit information regarding symptoms which may have occurred over a period of many years. If this is done with skill and thoroughness it will bear fruit in additional knowledge concerning the case.

There are few pathognomonic symptoms or signs in chest disease. The patient's statements must be analyzed and evaluated carefully and only consideration of all the data obtainable will lead to the proper diagnosis. Even in a matter apparently so simple as the date of onset of the present illness, further questioning may be required to be sure that the patient has placed enough emphasis on events seeming to him of a trivial nature or more rarely has not overemphasized the importance of symptoms in no way connected with his illness. A statement of his previous health and the most remote date of departure from his normal condition may establish the actual onset of his ill health. This is especially true in diseases that may progress silently, for example intrathoracic states. It should also be noted whether these symptoms occurred suddenly and with catastrophic violence or over a period of a few days and with less severity or gradually with increasing severity or so insidiously

that even an observant patient has no exact recollection of the onset

With some idea of the date and manner of onset of the illness it is important to discover any influencing circumstances. Did the symptoms follow the aspiration of a foreign body or result from severe physical effort or muscular strain? Were they apparently related to a previous infection or a cold? The history of 'grippe' or cold should be carefully analyzed and at the risk of appearing obtuse in the opinion of the patient he should be asked to describe his symptoms or explain what he means by grippe. It is remarkable what a variety of symptom complexes may pass under these diagnoses. Often a diagnosis of carcinoma of the lung has not been made until the condition was inoperable because the physician was lulled into a sense of security by a diagnosis of chronic bronchitis or failed to be suspicious of a story of recurring febrile attacks assumed to be grippe or flu.

After these details are known the whole course of the disease from its onset should be investigated. This part of the history should include the chronologic order of the appearance of symptoms as well as variations either quantitative or qualitative in symptoms already present. Detailed descriptions of the various symptoms by the patient should then be obtained and the physician should estimate whether he exaggerates, minimizes or evaluates them correctly. This appraisal is often aided by the amount of disability which the disease has caused such as whether the patient is still carrying on unlimited activity, has been forced to quit work or is bedridden.

No history is complete without the results of previous studies. Important evidence often is elicited when the patient recalls that he had a tuberculin test in school, a roentgenogram which showed a spot or a scar or a negative sputum examination. The statements of the patient's former physicians may also reveal information which otherwise would not be obtained. One should ignore no possible source of information even if it is only the patient's imperfect recollection of what was told him by his previous medical adviser.

Finally, knowledge of previous medical or surgical treatment and the results obtained is of value. For instance the history of a pneumothorax may explain present findings which would

otherwise be confusing. A favorable response to previous allergic management may emphasize the allergic condition and solve a difficult diagnostic problem.

SYMPTOMS

The symptoms in intrathoracic disease may be due to irritation, infection, obstruction or mechanical disturbance within the normal chest. They may also be due to cavity formation or dilatation of previously existing spaces to stretching or at times to reflex phenomena. These symptoms may be obvious in the chest or at some distance from it. It is also necessary to be aware that symptoms referred to the chest may be caused by disease or malfunction elsewhere. For instance, the precordial pain caused by gas in the splenic flexure of the colon or shoulder top pain caused by a diseased organ below the diaphragm.

The symptoms of thoracic disease are relatively few in number and the diagnosis is expedited by collecting as much information as possible about each one.

The symptoms are as follows:

- | | |
|--------------|--------------|
| 1 Cough | 7 Wheeze |
| 2 Sputum | 8 Hoarseness |
| 3 Hemoptysis | 9 Fever |
| 4 Pain | 10 Sweating |
| 5 Dyspnea | 11 Malaise |
| 6 Dysphagia | |

The last three of these, namely fever, sweating and malaise, are obviously general symptoms and not pathognomonic of disease in the chest. Hoarseness, if the larynx is not the site of intrinsic disease, may be caused by an intrathoracic lesion. The others immediately point to the chest as their source.

Cough

A cough is an explosive, forceful expiration, the physiologic purpose of which is to remove foreign material from the air passages. The cough reflex initiates in the larynx, trachea or bronchi down as far as the secondary branches. The pleura, especially that covering the diaphragm, is also sensitive and when irritated will produce cough. At times cough may arise from reflex irritation of the nose or ears, while occasionally psychic disturbances may seem to be the cause. Lesions in the

alveolae or smaller bronchioles will not cause cough unless they produce secretions which enter the secondary bronchi from whence in turn they are removed by cough. A simple dry cough is due to irritation of the tracheal or bronchial mucosa or the pleura or pressure on a bronchus from without or by a tumor or granuloma from within. A productive cough occurs when liquid materials must be removed.

Considerable information about the disease process may be obtained from an accurate description of this symptom. If it occurs spasmodically with each breath it is liable to be due to pleural or diaphragmatic irritation although the rush of air which accompanies a deep breath may irritate a lesion within the bronchi or may move secretions from one place to another and initiate the cough reflex. The inhalation of irritating gases or odors or smoke will cause spasmodic cough. As a result of such irritative agents an increase in bronchial secretions may require a cough at intervals to clear the respiratory passages. This cough is particularly likely to occur on arising in the morning and expels materials accumulated during the quiet respiration of sleep.

Persons with a large amount of bronchial secretion seem to develop a certain tolerance to its presence. It is not clear whether this is an abolition of the reflex from fatigue or whether it is due to destruction of the nerve ends by infection or inflammation within the mucosa. Perhaps one mechanism occurs in some patients and the other in the remainder. Probably due to destruction of the reflex arc many patients with advanced bronchiectasis seem to be able to accumulate large amounts of sputum before it gets up to an area where irritation occurs and cough begins. These people usually complain that changes of position especially stooping or lying down are followed by cough and expectoration a phenomenon of which we take advantage when we prescribe postural drainage. Thus the liquid material is spilled into the bronchi which have an active cough reflex and expectoration results.

A cough which comes after a period of malaise or fever and is followed by profuse expectoration with a rapid drop in temperature and improvement in the general condition is characteristic of the release of a bronchial obstruction. It permits the drainage of secretions entrapped beyond the obstruction from

which absorption of toxic agents results. This may occur repeatedly in the same patient either because a bronchus which is partially closed by congenital defect or disease has become completely closed by an exacerbation of the disease or by thickened secretions or on the other hand because of obstruction from excessively viscid secretions. The latter is particularly likely to occur in allergic individuals.

Sputum

When the physician has learned as much as possible about the cough and influencing factors he should proceed to a study of the sputum. If simple irritation is present the sputum should consist of clear mucoid material. In a few of our patients a thorough study has failed to reveal any organic cause for the excess bronchial mucus. Some of these were emotional nervous patients with various psychic disturbances who under stress seemed to secrete large amounts of mucus and to cough. The situation is similar to a person with so called mucous colitis who discharges large amounts of intestinal mucus when similarly disturbed. This condition we have termed mucous bronchitis for want of a better term.

When infection is present the sputum is altered depending on the organism or organisms. Certain fungi and the Friedlander bacillus cause the sputum to be excessively viscid and sticky. The pyogenic organisms produce first a mucopurulent and later a frankly purulent sputum. If anaerobic organisms or fusospirochetal bacteria predominate the odor is usually foul. The amount of secretion gives some indication of the severity of the condition or the activity of the infectious process. Tuberculosis often causes a greenish sputum and a large or small amount of mucus containing smaller flecks or purulent material. Bronchial casts may occur rarely in pulmonary tuberculosis as well as in chronic nonspecific bronchitis and in the form of pearls of Laennec in asthma or asthmatic bronchitis. Curschmann's spirals are pathognomonic of bronchial asthma. Bronchiectasis or abscess usually produces the familiar sputum which separates into layers on standing but is not always malodorous. Purulent sputum coming in a sudden gush and in large amount may indicate the discharge of an empyema collection or an abscess into a bronchus. A gush of a quantity of clear mucus follows the rupture of a cyst and

if this is a dermoid it may contain hair (a pathognomonic sign) Flecks of stony material may be expectorated when a calcified gland erodes into a bronchus

Infection is not the only cause of expectoration The break down of tissue as in the presence of gangrene or a tumor may also produce it in varying amounts and it may or may not have a characteristic odor or appearance A frothy sputum means it has been mixed with air This occurs in asthma in heart failure and with some infections particularly yeast

Hemoptysis

Finally the presence of blood should be noted carefully Hemoptysis may result from any of the diseases of the lungs bronchi or mediastinum Statistically it has been shown that some conditions frequently cause bleeding and others rarely do but in diagnosis this is of little help First a determination must be made of whether hemoptysis has actually taken place This is not always as easy as it would seem and repeated observations may be required especially during the hemorrhagic episode as well as the usual careful history and examination Hematemesis bleeding gums and epistaxis which are often a cause of confusion must be excluded Jackson and Diamond¹ in a recent bronchoscopic study of patients admitted for hemoptysis of nontuberculous origin listed nineteen different diseases which cause bleeding Of 436 patients with hemoptysis over half could be accounted for by bronchiectasis and carcinoma of the bronchus Surprisingly however in approximately 17 per cent no cause other than a simple tracheobronchitis could be found and in 8 per cent no cause at all

Aside from definite lesions in the lungs or bronchial tree bleeding will occur as a result of disturbances in the clotting mechanism due to blood dyscrasias or deficiencies of vitamin C and probably also vitamin K Pulmonary hypertension caused by valvular heart disease failing left ventricle with pulmonary congestion or elevated systemic blood pressure may be an occasional cause of puzzling hemoptysis Of particular interest to the surgeon is the pulmonary infarct which often manifests itself during the postoperative period by the expectoration of blood

Dangerous loss of blood is rare except in tuberculosis bronchiectasis and pulmonary abscess However in any quantity it

should be considered as a warning of possible serious disease and the diagnostician never should be satisfied until he is absolutely sure the cause has been found. He should not forget the possibility that two causes for hemoptysis may be present in the same patient: that is, the tuberculous patient may also develop carcinoma of the lung and the hypertensive patient may have bronchiectasis or tuberculosis. Hemoptysis is the indication above all others for bronchoscopic study unless the diagnosis can be made without doubt by other means.

Bleeding may vary from an exsanguinating hemorrhage to a tiny streak. It may occur once or often and in either case it must be explained. The nature of the bleeding may be of some help. Bright red blood means fresh hemorrhage; dark blood is partially changed and may have been retained for some time. Blood on the surface of the sputum or streaked through it usually means a superficial lesion, while blood thoroughly mixed with sputum means a more deeply situated lesion. The frothy, bloody or pinkish sputum of acute pulmonary edema is as typical as the rusty sputum of heart failure. Sputum of the prune juice type of lobar pneumonia. Frequently repeated large fresh hemorrhages indicate lively bleeding from a large open vessel and may demand active intervention such as collapse of the lung.

Pain

Pain is a common symptom in disease of the chest, however many lesions may appear and run their entire course without once causing any local discomfort. This occurs because the pulmonary parenchyma is devoid of pain fibers. Irritation, inflammation or pressure on the trachea or larger bronchi may cause a certain amount of dull ache or discomfort, but only involvement of the pleura will cause sharp or excruciating pain. Therefore any disease causing pain must be assumed to involve either bronchi or pleura. Pleural pain is not always influenced by respiration as it is when the causative factors include the rubbing of the inflamed surfaces in a dry pleurisy. Malignant invasion of the pleura may cause pain of more constant type. Stretching of the pleura as in a spontaneous pneumothorax with positive pressure may cause pain relatively little influenced by the phase of respiration.

No symptom requires more careful analysis than the subjective

complaint of pain. The examiner often finds a lesion which he may readily believe causes the patient much discomfort but in the final analysis it is usually the patient's statement which alone provides the diagnostic clue. As previously indicated a description of the type of pain is often helpful that is whether sharp dull shooting or colicky and whether influenced by respiration. Many other things may influence a pain such as swallowing coughing sneezing straining and the position of the patient. The significance of most of these is obvious. The thoughtful examiner will know at once that pain caused by swallowing implicates the esophagus that pain coming on while in the recumbent position suggests diaphragmatic hernia or heart pain with coronary involvement particularly in active infarction of the myocardium and that pain occurring during respiration the pleura. However the physician concerned with thoracic disease invariably encounters a certain number of patients whose chief complaint is pain in the chest but whose symptoms are due to angina pectoris or coronary disease. The relationship of this pain to exertion excitement and rest gives valuable diagnostic information. Similarly a certain number of people have pain due to arachnoiditis radiculitis dorsal vertebral disease or even spinal cord tumors. Careful attention to the effects of position muscular strain and cough which raise intraspinal pressure will often give the first indication of the true significance of the symptoms.

Under these circumstances it is also helpful to get the patient's idea about the location of the pain not only with regard to the side of the body involved but also its depth that is whether it is superficial or deep within the chest. Often the pain of chest wall disease feels to the patient so superficial that he can almost touch it while the pain of mediastinal disease is deep and much more poorly localized. In line with the localization of pain the radiation of pain and its reference to near by or remote areas may cause confusion as to the site of origin. For example the well known radiation of pain from the lower pleura to the upper abdomen may be cited. All surgeons are aware of this in the differential diagnosis of acute abdominal emergencies particularly those occurring in the upper abdomen. It is not so easy to remember that diaphragmatic irritation may cause pain on top of the shoulder which might be confused with a subacromial

bursitis that cardiac disease may cause pain in the neck, shoulder, arm or back, and particularly that esophageal disease may cause pain referred to exactly the same areas as angina pectoris. An apical pulmonary tumor, cervical arthritis or a scalenus anticus syndrome may cause pain radiating to the arm so similar in type that even careful analysis will not reveal the cause until each possibility has been considered and ruled out by other methods.

The reverse is also true, namely, pain initiated elsewhere may be felt in the chest. The precordial pain of a gas-filled stomach or colon is familiar. Perisplenitis may cause symptoms indistinguishable from a basal pleuritis. Perhaps less commonly recognized is the fact that the pain of a gastric malignancy or peptic ulcer may appear substernally and that a posterior penetrating duodenal ulcer may cause pain in the back or radiating pain around the right lower chest or costal margin.

Finally, valuable information may be obtained by a knowledge of the measures which may be used to relieve the pain. Alkalies, milk or food will relieve the pain of an ulcer but not of radiculitis. Strapping the chest relieves pleurisy but not the referred pain of a distended bowel. Cessation of all activity or the use of nitroglycerin may quickly abolish the arm pain of angina but will not influence that caused by an apical pulmonary tumor. These are helpful bits of information in clear-cut cases but otherwise some nicety of judgment is required to avoid the well-known suggestibility of patients and mistakes in those instances in which the results are equivocal. Usually these findings are valuable as suggestions for further study rather than as diagnostic in themselves.

Dyspnea

Dyspnea is an extremely variable symptom highly colored by the patient's own powers of observation and temperamental makeup. It is entirely unrelated to the amount of disease present. By familiar usage, dyspnea means not painful but labored or difficult breathing or shortness of breath. The patient's complaint of shortness of breath must always be carefully analyzed to rule out the sighing respiration associated with nervousness which has no organic basis. Extrapulmonary conditions may be causative. Heart disease, uremia, acidosis and abdominal dis-

tention must be considered. Dyspnea may occur constantly even at rest or only on exertion. It may be paroxysmal as for example in asthma or intermittent bronchial obstruction. In the latter instance it is relieved by coughing or raising sputum. Shortness of breath occurs in spasm or obstruction of the larynx, pressure on or obstruction of the trachea or larger bronchi, partial obstruction of the smaller bronchi or extensive alveolar disease. These causes are all more or less structural, the dyspnea being due to the mechanical difficulty of getting air through a narrow opening. This is demonstrated by the relative ease with which these patients can inhale the light helium oxygen mixture as compared to the usual nitrogen oxygen mixture found in the air.

Nearly all of the other causes of dyspnea are mechanical also but in a somewhat different manner. These are factors which limit the ability to alter the size of the chest thus bringing about increased respiratory effort and dyspnea. This may be caused by collections of pleural fluid, tumors, adhesions, spondylitis, scoliosis or a barrel chest which affects the motion of the chest wall or by pulmonary fibrosis or pneumothorax, which limits the motion of the lung itself. Except in extreme cases the amount of inactive lung tissue does not seem to be much of a factor. For instance, a partially obstructed bronchus may cause more dyspnea than a totally obstructed one which completely removes the affected area from the respiratory act. In the final analysis even the dyspnea caused by pneumonia, bronchiolitis, pulmonary edema or interstitial fibrosis may be considered mechanical because in these conditions oxygen exchange is handicapped by alveolar exudate or thickening of the alveolar endothelium which constitutes a barrier to the free passage of gas from the alveolus to the blood stream. The exceptions are dyspnea caused by decreased cardiac output or diminished oxygen carrying capacity of the blood as in anemia or carbon monoxide poisoning. Pulmonary emboli even though small may cause enough reflex spasm of the pulmonary arterial tree to reduce seriously pulmonary circulation and cause dyspnea all out of proportion to the size of the precipitating lesion.

Dysphagia

Dysphagia indicates of course that the esophagus is involved either directly or indirectly. One must ascertain whether swal-

lowing is painful or only difficult. Pain is common in malignant esophageal disease and rare in other conditions. The patient may have difficulty in initiating the act of swallowing or trouble in getting food to pass through the esophageal tube into the stomach. The former is characteristic of a disturbed neuromuscular mechanism and is found in the various forms of bulbar paralysis while the latter is suggestive of mechanical blocking in the esophagus itself. Hysteria of course must be considered. The fact that dysphagia is intermittent does not necessarily rule out organic disease though this symptom favors its benign origin. Lesions in the upper one third of the esophagus are prone to be associated with overflow of esophageal contents into the trachea with subsequent cough and often pulmonary inflammation. The regurgitation of unchanged food eaten many hours before is usually found in diverticulum of the esophagus or cardiospasm with dilatation above it. This may occur only when the patient assumes the recumbent position. He usually feels the pain or the sense of obstruction either in the suprasternal notch or the xiphoid region and only rarely feels it substernally regardless of the site of the actual lesion. The pressure of a benign tumor of extra esophageal origin may cause as much obstruction as the rare benign esophageal tumor. An enlarged heart encroaching on the posterior mediastinum especially the large left auricle found in mitral stenosis is an occasional cause of dysphagia.

Hoarseness

Hoarseness is much less commonly caused by thoracic disease. However, in case the larynx itself shows no intrinsic lesion and particularly when a unilateral vocal cord paralysis (usually the left) is present a search should be made for an intrathoracic cause. The commonest finding is a lesion pressing on the recurrent laryngeal nerve as it passes under the arch of the aorta and above the lung root. Pressure from above commonly is due to an aneurysm of the aorta from below to the enlarged left auricle of a rheumatic heart with mitral stenosis or to a tumor in the hilum of the left lung. Malignant infiltration of the mediastinum may involve the nerve with similar results and is always an indication of the inoperable nature of the lesion.

Wheeze

A wheeze which is the final specific symptom of thoracic disease is extremely important because it invariably indicates partial bronchial obstruction. Elicitation of this symptom by subjective or objective means is most important because it may be the only indication of involvement of the bronchial tree and as often as not even the roentgenogram may show nothing to suggest such a lesion. Bronchi of normal diameter never permit the production of a wheezing sound. Narrowing by bronchial spasm as in asthma, solid material as by a foreign body, a tumor or liquid as in bronchitis or pulmonary edema is the *sine qua non* of the wheeze. It may be intermittent or permanent of course depending on whether the causative factor can be removed or altered in position. Too, it may be localized to one area of the lung or heard equally well throughout. In this connection lesions in the trachea or larger bronchi may set up vibrations in the entire column of air within the tracheobronchial tree and the sounds so produced will be distributed widely. The quality of the sound is of some importance but its occurrence in inspiration or in expiration is of little diagnostic value.

The stridor of tracheal compression must be distinguished from the more highly pitched wheeze of an obstructed bronchus, the snoring and whistling sounds of mucus in the smaller bronchi and the squeaks produced in the bronchioles. The change in diameter of the bronchus during the phases of respiration may alter the timing of the wheeze. For instance a small tumor may cause no great amount of obstruction while the bronchus is dilated during inspiration and air may pass it noiselessly. However during the narrowing characteristic of expiration partial obstruction and therefore wheeze may occur. As the same tumor grows a little larger it may nearly obstruct and thereby produce wheezing during inspiration and completely obstruct during the contraction of the expiratory phase and thus allow no wheezing.

Fever, Sweating and Malaise

Fever, sweating and malaise are by no means specific symptoms of pulmonary disease but they occur frequently and are often helpful diagnostically. Moreover they may be the only symptoms of a pulmonary lesion. When fever, malaise, sweating

debris and secretions lavage preceded esophagoscopy. This procedure was done either under local or general anesthesia depending on the temperament of the patient. A 53 cm esophagoscope fitted with lens and bulb for distending the esophagus with air was used to visualize the entire esophageal wall and made finding of the narrow passage into the stomach quite easy even when the esophagus was markedly dilated and tortuous.

TREATMENT

Treatment was begun by removing the lens and passing a Tucker Plummer dilator through the esophagoscope into the stomach. The esophagoscope was withdrawn into the esophagus and the dilator inflated to 15 pounds pressure which gives a dilatation 1 inch in diameter (75 F). The dilator was withdrawn and the esophagus again visualized.

A second dilatation was made in from two to five days using a modified Plummer dilator $1\frac{1}{4}$ inches in diameter (95 F). This procedure was carried out before the fluoroscope checking the position of the dilator. The dilator was inflated until quite severe pain resulted or until the full dilatation of the instrument was reached never using more than 15 pounds of pressure to the inch.

The first dilatation was performed in the hospital and the others in the Clinic. In the latter case the patient came in early in the afternoon having had no food since a light breakfast. A 2 per cent pontocaine solution used as a spray to anesthetize the pharynx decreased gagging and made the procedure easier for the patient. The fluoroscope was used to check the position and size of the dilator.

In addition to mechanical dilatation instructions were given concerning careful mastication of food. The patient was told to avoid food that could not be well masticated such as raw fruits and vegetables with fibers or skins and tough firm meats. Such meats should be ground and cooled in some form such as meat loaf. Foods containing much fiber and shell such as lima beans should be run through a ricer. Warm drinks following a meal to help empty the esophagus were also advised.

One patient in whom satisfactory results were not obtained was taught to lavage his esophagus at bedtime to avoid regurgitation and the danger of lung suppuration or abscess.

RESULTS

Nine of the 75 patients were relieved of esophageal symptoms by this treatment alone. The patient with severe lung suppuration was relieved of the esophageal symptoms but not of the lung suppuration. Six patients who had a second dilatation are symptom free as are 2 patients who had three dilatations. Two patients who had four dilatations are symptom free. Of 3 patients who had five dilatations 2 are symptom free and 1 markedly improved. Two patients who had six dilatations have had excellent results. 1 had marked lung fibrosis and the other had a gastrostomy which has been allowed to close. One patient had seven dilatations since the result was poor he has been unwilling to have further dilatations as long as he is able to maintain his weight. This patient has an S curve which makes it more difficult to pass the dilator than in most patients.

In the 25 consecutive cases 1 patient (4 per cent) has had a poor result. In this case surgical intervention is justifiable but he has refused such a procedure. One patient (4 per cent) has had a fair result. Ninety two per cent of patients have obtained an excellent result from dilatation and dietary care however most of them have become somewhat careless about dietary management since they can eat almost anything without immediate detrimental result.

THE TREATMENT OF DIABETES IN RELATION TO SURGICAL OPERATIONS

FRANK N. ALLAN

In an analysis of 100 cases of diabetes treated at the Lahey Clinic recently special attention was given to the surgical procedures undertaken and to the measures employed in dealing with the diabetes at the time of operation.

Twelve major operations were performed on 10 patients. The operations included four thyroidectomies, two hysterectomies, two cholecystectomies, one repair of the common bile duct with stricture, and three miscellaneous operations. There were four minor operations. In addition, three major operations had been performed elsewhere. Sixteen of the 100 patients had a total of nineteen operations.

Approximately 1 in 6 of the diabetic patients who came for treatment in this limited period had surgical therapy. In the years to come a larger proportion of the group ultimately will need surgical treatment for one reason or another. Most of these patients had had diabetes for only a short time. 41 per cent of them had no knowledge of diabetes before they came to the Clinic. Most of them should live close to the average lifetime with adequate attention to diabetic treatment in the future. As these patients approach old age, carcinoma undoubtedly will occur in some cases and necessitate operation. Certain individuals may require surgical treatment for gangrene, even with attention given to preventive measures. Diabetic individuals will also have their share of other conditions requiring surgery. Hence at least 1 in every 3 or 4 diabetics can expect eventually to undergo surgical operation. It can readily be seen that control of diabetes at the time of operation is a problem which must be faced frequently.

Simple rules regarding the treatment of diabetes in relation to surgical operations have been followed successfully at this Clinic. They are presented briefly herewith.

PREOPERATIVE TREATMENT

The usual diabetic diet is employed and insulin is prescribed as needed to control glycosuria. In most cases the carbohydrate content of the diet is 132 to 165, the protein 70 to 90 and the fat 50 to 150 gm, the amount of the fat depending on the caloric needs. Vitamin supplements are not prescribed routinely but are given when there is evidence of poor nutrition as a result of previous neglect.

Protamine insulin in a single dose before breakfast is used if the amount of insulin needed to control glycosuria is 30 units or less. When more than 30 units are needed the morning dose of protamine insulin usually is supplemented by an injection of 10 to 25 units of regular insulin before breakfast and in a few instances by another injection of 5 to 15 units of regular insulin before the evening meal. Absence of glycosuria and reduction of the blood sugar below 160 mg per 100 cc are desired but are not essential. The presence of sugar in the urine during part of the day or high blood sugar need not delay an emergency operation unless the patient has ketosis. On the other hand there should not be haste in undertaking an elective operation if the patient is in a weakened condition because of previous neglect of diabetic treatment.

Insulin

The usual dose of protamine insulin is given the morning of the operation. In addition unmodified insulin is given under three circumstances: first if the diabetes is severe (as indicated by requirement of more than 30 units of insulin daily), secondly if the urine contains sugar and thirdly if the blood sugar is above 150 mg. The dosage of regular insulin must be small to avoid the risk of hypoglycemia in the operating room. Not more than 5 or 10 units of such insulin should be given unless nourishment is given by mouth or dextrose is given by intravenous injection.

Preoperative Nourishment

Nourishment should be provided before operation if the diabetes is severe or if it is complicated by hyperthyroidism. Oral administration seldom is desirable and when nourishment is needed intravenous infusion of 500 to 1000 cc of fluid con-

tuning 50 to 100 gm of dextrose is preferred. At the time of the intravenous injection insulin is given subcutaneously allowing 10 units for each 50 gm of dextrose; this amount is added to the regular amount of insulin to be given at the time.

POSTOPERATIVE TREATMENT

As a rule intravenous infusions are given as would be indicated in the uncomplicated surgical case but as noted in the discussion of preoperative nourishment cases of severe diabetes and cases in which the diabetes is complicated by hyperthyroidism need special administration of dextrose. Under such circumstances insulin also has to be given as needed to provide for its assimilation. If the patient is unable to take nourishment by mouth he should be given 1 000 to 2 000 cc of 5 or 10 per cent dextrose solution. The total intake of dextrose in twenty-four hours should be at least 125 to 150 gm. An extra 10 units of insulin should be given subcutaneously for each 50 gm of dextrose given intravenously.

Diet

If the patient is able to take nourishment by mouth he should be given liquids and soft foods containing the equivalent of 50 to 75 gm of carbohydrate. If only liquids can be taken one may use fruit juices, ginger ale, gruel, broth and tea with cream and sugar. As a rule a minimum of 50 to 75 gm of carbohydrate can be given in this form. The supplementary feeding with intravenous injections of dextrose will bring up the total intake to the desired level of 150 gm.

Standard postoperative diets are employed for the first three to six days after a major operation. Later the regular diet may be modified to suit the patient's appetite and clinical condition. After a minor operation the patient may be permitted to take his full diet immediately.

Insulin

When insulin has been employed before operation treatment is continued using the usual dose of protamine insulin in the morning. Supplementary doses of unmodified insulin are given before meals or at bedtime, the amount depending on the laboratory tests. Tests of the urine are made four times daily and

blood sugar tests are ordered frequently. A blood sugar test is made routinely at 4 P.M. on the day of any major operation if the diabetes is mild and at both 11 A.M. and 4 P.M. if the diabetes is severe. Additional tests are ordered when there is any doubt as to the patient's diabetic status. In general, blood sugar tests made at 11 A.M. and 4 P.M. are of greater value in guiding the adjustment of insulin dosage than tests made only in the morning before breakfast.

It is rarely possible to prevent transitory glycosuria after intravenous injections of dextrose. Care should be taken to avoid being misled by tests of the urine which show a large amount of sugar when injections are being given. As a rule they must be disregarded if the tests before injection are satisfactory. A blood sugar test should be made two hours after completion of the injection in case of doubt.

It is common practice to order insulin routinely according to the color of the Benedict's reaction—20 units of insulin when red, 10 when green, and none when blue. This plan has limited usefulness; it may lead to overdosage in the evening and underdosage in the morning. One must consider not only what the test of the urine shows at any specified time but also how much insulin is already at work from injections given earlier in the day. This is especially true when protamine insulin is employed since its slow action may lead to delayed hypoglycemic reactions. A red test may indicate the need for 20 units of insulin in the morning, but with such a test in the evening, 5 units may be too much if large doses have already been given earlier.

In case of uncertainty regarding the proper dose of insulin it is wise to give less rather than more than seems to be needed. If all the tests of the urine show sugar, one should give large doses of insulin boldly in the first part of the day but in the evening it is imperative to use caution.

Insulin reactions rarely cause any serious difficulty, but sometimes occur unexpectedly, particularly when large doses of insulin have been given to control severe diabetes and when there has been irregularity in the assimilation of food. A reaction should be suspected whenever there are any unusual complaints or behavior. In case of doubt, treatment for a hypoglycemic reaction should be given. As a rule, one fourth glass of orange juice or a teaspoonful of sugar should be given orally. If the

patient is unable to take food by mouth he should be given 5 gm. or more of glucose intravenously or 0.5 cc. of adrenalin by hypodermic injection. If a severe reaction occurs after a large dose of protamine insulin these small amounts of food or glucose may have to be repeated to prevent relapse.

Even when insulin has not been employed before operation it is likely to be needed temporarily after a major procedure or after any operation in which a general anesthetic is given. If there is sugar in the urine or a rise in blood sugar 5 or 10 units of regular insulin are given at each meal for the first day or so. If more than 20 to 30 units are required for twenty-four hours approximately half may be given as protamine insulin in the morning and the remainder in doses of regular insulin at each mealtime the size depending on the laboratory tests.

RESULTS

In the group of cases studied the results of operation were satisfactory and there was no mortality. Of course this group was small and in a large series one would find that the surgical mortality would equal but should not exceed the average surgical mortality in corresponding groups of nondiabetic cases.

With attention to the control of diabetes persons with diabetes can expect to have surgical treatment with the same safety and success encountered in nondiabetic cases.

THROMBOPHLEBITIS DIAGNOSTIC METHODS AND SELECTION OF TREATMENT

RALPH ADAMS

ACUTE THROMBOPHLEBITIS

FEW diseases are as easy to diagnose and as difficult to treat as thrombophlebitis. The syndrome consisting of an acutely swollen, hot, painful lower extremity subsequent to childbirth, trauma, or major operation is all too familiar to every physician. In nearly every case of thrombophlebitis careful questioning will elicit a history of some antecedent difficulty with the veins and the most common fact encountered is the preceding existence of superficial varicosities. However, an occasional case with no ascribable cause is seen. Many explanations have been advanced for the frequency of thrombophlebitis after certain procedures. Its occurrence after lacerations and trauma has been attributed to direct injury of the vein intima by blows to hemoconcentration and to peripheral stasis from shock. The stirrups in which the legs of patients are held in lithotomy position for pelvic and perineal operations have been criticized as causing injury to the veins by direct pressure, acute angulation, and blockage of return blood flow. Extension of thromboses from veins ligated in the course of pelvic operations is held accountable for numerous pulmonary emboli, and infection in an upper abdominal wound often precedes by a few days the onset of acute phlebitis.

Thrombotic occlusion of the femoro iliac vein which initiates the clinically typical disease of phlegmasia alba dolens is characterized by fever, leukocytosis, pain, and swelling of the entire leg, cyanosis, and lowered surface temperature of the lower leg. The leg is heavy from engorgement, tender to pressure, and painful on movement. Lesser degrees of involvement, however, are more commonly encountered, and the clinical symptoms and signs diminish in direct proportion to the distance of the inflammatory thrombosis from the heart. Unfortunately, the fewer the symptoms caused by thrombophlebitis, the greater is the danger of fatal pulmonary embolism.

A typical case of acute thrombophlebitis can be summarized as follows. Sometime between the tenth and sixteenth day after a major operation the patient complained of slight pain in the calf of the leg. Dorsiflexion of the ankle caused increased pain in the calf muscles which were also painful when directly squeezed between the fingers and thumb. On reviewing the clinical chart the temperature course had been slightly abnormal from the third postoperative day and at least once daily a rise of temperature to 99° F had occurred. Not infrequently the patient had failed to mention the slight discomfort in his leg until after he had had a sudden sharp pain in the chest followed by blood tinged sputum when the previously mentioned facts were elicited by direct questioning and examination.

In this type of case at least a warning is given that the veins may be in trouble and that a pulmonary catastrophe is imminent. In another type of case however no warning symptom or sign occurs and after a pulmonary embolus has developed critical review of all data fails to show any indication that a thrombus was propagating. In other words there is thrombosis without infection and to this condition the name *phlebotrombosis* has been applied.⁴

Careful evaluation of the distribution of tenderness and swelling is helpful in differentiating between superficial and deep phlebitis. In the former the tenderness is superficial and the thrombosed venous segment is easily palpated by virtue of the inflammatory induration which follows the course of the vein in distinction to the generalized muscle tenderness of deep thrombophlebitis. The swelling is localized and does not involve the circumference of the leg.

Considerable controversy has raged about the *venogram* as a diagnostic measure.⁵ Its proponents believe that injection of an opaque medium into the short saphenous vein at the ankle reliably outlines the normal deep venous system on roentgenologic examination that it is of localizing value in placing the site of thrombosis and therefore a valuable operative guide to the site of occlusion for prevention of pulmonary emboli. They believe the test itself is without danger and that its bilateral use will exclude or verify a silent thrombosis.

The opponents of the *venogram* believe that it may fail to show a silent occlusion because it sometimes fails to show a

thrombus even in the presence of definite symptoms and signs suggestive of deep thrombophlebitis that it gives a false sense of security and that it is not of localizing value

We believe the venogram is helpful in trying to decide from which leg a sublethal infarct has originated

Treatment

The treatment of acute thrombophlebitis is directed toward control of the immediate inflammatory process the release of vasospasm the prevention of pulmonary embolus and the avoidance of late sequelae of thrombosis in the leg Phlebitis in even a small area of vein may cause marked reflex spasm of both the veins and arteries of the extremities As a result of venous spasm the venous pressure is increased leading to relative tissue anoxemia, loss of differential filtration potential in the capillary membrane and edema Reflex arteriospasm results in impedance and diminution of the arterial blood flow reflected as stagnation in the peripheral vascular bed and accentuates the tendency to edema Persistent edema leads to irreversible subcutaneous fibrosis and chronic disability If in addition to the time honored methods of *heat* and *elevation* to arrest the acute process one can interrupt the cycle by which vasospasm is established the clinical response may be dramatic The effectiveness of sympathetic nerve block in breaking the vasospastic reflex is now supported by hundreds of cases The technic of *pars intertubal lumbar injection* is so simple that the procedure can and should be applied to every case of phlebitis as soon as the diagnosis is made Our policy is to inject 10 cc of 1 per cent novocain on the anterior lateral surface of each of the four upper lumbar vertebrae This is in immediate proximity to the sympathetic chain and there is proof of successful injection if within ten minutes the lower extremity becomes warm and dry We repeat the injection at daily intervals for at least three days and thereafter until the fever subsides Novocain is preferred to alcohol because there is no danger of necrosis or delayed neuritis and it is preferred to lumbar sympathectomy because of its simplicity A maximal vasodilative response is obtained with each injection

In accordance with our most recent policy the first sign of acute thrombophlebitis is an indication not only for the measures

just mentioned but also for immediate *anticoagulant therapy*. Heparin by vein and dicumarol by mouth are administered at once. The heparin effect is apparent within a few hours but the dicumarol effect does not appear until about the third day. By this combination of drug therapy intravascular thrombus propagation is combated. The tedious expensive regimen of heparin administration and control by determinations of clotting time is limited to a few days. Thereafter by oral dosage of dicumarol the blood engorging tendency may be reduced for as long as necessary and controlled by determinations of the prothrombin time.

Under this program femoral vein division is no longer being done in acute thrombophlebitis to forestall the occurrence of a pulmonary embolus and if experience proves that anticoagulant therapy is sufficient in itself a great advantage will be the avoidance of operation upon the great leg veins.

At present we believe however that in the presence of signs of deep thrombophlebitis in the lower leg or popliteal veins and a warning sublethal pulmonary infarct the superficial femoral veins should be ligated and divided. If there has been a pulmonary infarct without localization as to side venograms should be made. If one side is negative the other positive or equivocal the second side should be ligated and divided. If both sides are negative with technically excellent venography the embolus probably has arisen elsewhere than in the legs. If both sides are equivocal and remain so when the venograms are repeated both sides should be ligated and divided.

Whenever a femoral vein is to be divided free flow should be proved from above the point of opening and the upper end of the vein should also be aspirated with a catheter. If there is clinical and venographic evidence that the femoro iliac vein is blocked the incision should be made at or just above the groin crease. If the femoral vein is opened at the saphenofemoral junction and no clot is found the opening can be closed easily by ligating the saphenous stump and the superficial femoral vein then divided. If a clot extends into the common femoral and iliac vein it should be aspirated and the femoral or iliac vein divided. This will result in considerable edema of the leg in contrast to division of the superficial femoral vein which need not be followed by troublesome edema provided elastic

bandages are worn whenever the patient is out of bed for six months afterward. After removal of a venous thrombus or division of a vein because of a preceding pulmonary embolus anticoagulant therapy should be instituted in the form of heparin and dicumarol.

CHRONIC THROMBOPHLEBITIS

In practically every case of chronic thrombophlebitis a previous history of milk leg, acute phlebitis or inflammation can be elicited, but in rare instances determination of the time or nature of onset is impossible. One learns by questioning that the leg may become edematous shortly after arising in the morning, that the edema subsides at night but that the leg never returns entirely to normal size. Increased sweating in the involved extremity is often present. When an elastic bandage is worn with obliterative disease in the deep system the patient complains that swelling either occurs under the bandage or that the leg feels as though encased in a vice. Swollen tissue rolls over the upper and lower margins of the elastic support to the accompaniment of increasing pain. In a majority of cases trouble some fungous infection is found, which is not surprising since a moist skin with a low surface temperature furnishes an ideal environment for epidermophytosis. Deep, painful, punched-out ulcers below the calf muscles and around the malleoli are common.

Superficial varicosities may exist to a marked degree and demand careful consideration before surgical obliteration to make certain they are not a compensation for an obstructed deep system. If they are compensatory, inquiry usually reveals that the varicosities appeared subsequent to the initial attack of acute phlebitis and the swelling. Such veins become more engorged instead of less prominent as with incompetent superficial venous varicosities when a tourniquet is applied lightly at the knee and the patient made to exercise the foot. As they become engorged, pain in the leg increases until the tourniquet must be removed. If in the recumbent position the edema subsides rapidly, it indicates that the lymphatic pathways are open, but if subsidence of edema requires many hours, lymphatic disease in addition to venous disease probably exists. If after elevation of the leg the brawny induration fails to subside, lym

phatic obstruction and tissue damage have advanced to the point of subcutaneous fibrosis commonly called chronic sclerosing lymphedema.

An ulcer in such tissue is hard to cure. The ever present fungous infection, the constant tissue anoxemia, the underlying thickened fibrotic fascia, and the venous blood stagnating in neighboring communicating veins provide a background ill suited to the growth of healthy granulation tissue and the propagation of cutaneous epithelium necessary to heal an ulcer. In addition, reflex arterial spasm often is apparent, accounting further for inadequacy in tissue oxygenation and persistence or recurrence of ulceration.

Treatment

Although a cure for deep thrombophlebitis with ulceration has not been discovered, a number of helpful diagnostic and therapeutic procedures have been developed in the last ten years. Vigorous *prophylaxis* in the postpartum and postoperative hospital wards should reduce significantly the incidence of acute thrombophlebitis. This includes a propaganda campaign among physicians, nurses, and patients to keep the patient's feet and legs moving after delivery or operation. We now have a standing order which reads: "Make the patient exercise his toes and ankles 1,000 times a day." Those patients with varicosities should have their legs bandaged before and after operation. An adequate fluid intake should be maintained. Tight abdominal strapping should be avoided, as well as positions which cause acute flexion of the thighs or knees.

If acute thrombophlebitis supervenes, a paravertebral lumbar block should be done at the onset of the first symptom, which usually is pain in the calf of the leg. Although sufficient confirmatory statistical information is not yet available, it seems that the early use of anticoagulants (heparin followed by dicumarol) after the first symptom of postoperative phlebitis not only may reduce the hazard of clot propagation and pulmonary emboli but also the frequency of late edema and other distressing sequelae.

In chronic thrombophlebitis with ulceration and superficial varicosities, the general program of investigation and treatment is as follows. The usual Trendelenburg and tourniquet tests

are applied to determine whether the varicosities result from incompetence in the valves of the superficial saphenous system or whether they are present by necessity for return blood flow. Whether the application of effective elastic support increases or decreases the discomfort is determined. A venogram is done to determine the patency of the venous channels. The following combinations may occur:

1 The deep system venogram looks normal, outlining the anterior and posterior tibial and peroneal veins, the popliteal vein and the femoral vein. This finding indicates that the thrombophlebitis is of the superficial system; that such edema as exists is secondary to varicose vein reflux; and that an ulcer is present because of stagnation in neighboring or underlying varicose veins. We ligate the long saphenous vein at the saphenofemoral junction, inject the lower leg varicosities, treat the ulcer by local hygienic measures, prescribe an elastic support for ambulatory patients, and expect to obtain healing in a high percentage of cases. Occasionally there will be a normal appearing venogram of the deep saphenous system without superficially detectable varicosities but with a thickened, chronically edematous leg. In this case the diagnosis may be chronic sclerosing lymphedema on a background of lymphatic infection in which persistent uncontrolled epidermophytosis of the feet plays a prominent role. On the other hand, one may assume that old deep phlebitis has existed but that perfect recanalization has occurred; however, this is unlikely as recanalization is usually easy to detect in a good venogram.

2 The entire deep system may be occluded and all the opaque medium ascends through the saphenous vein to the groin where it may be observed reentering the deep vein, possibly with a short reflux down the femoral vein just below the saphenofemoral junction. In this situation we feel most helpless. Since the deep system is useless and the superficial system is varicose, the leg will remain swollen whatever is done, and it is almost certain that if the ulcer is healed it will recur. Such a patient must prove his willingness and ability to cooperate before we will undertake surgical treatment. If he is fat, he must reduce under dietary supervision. If his ulcer is dirty, his feet unkempt, and his habits careless, he must prove that he can keep his feet clean and be meticulous in his hygiene. Otherwise the expendi-

ture of time effort and money in trying to help him surgically is wasted because failure will be the end result. If however he does cooperate we are willing to sympathectomize the leg excise the ulcer including the fascia and apply a thick Thiersch graft after granulation tissue has formed in the bed of the wound. With reasonable opportunity to elevate the leg at stated periods during the day and exacting attention to hygienic routine the use of such elastic support as is tolerable some of these patients can be kept well. Naturally high saphenous ligation is not done.

3 The dye may ascend through normal looking deep veins to the knee but there be shunted through the veins about the knee into the superficial system and the femoral vein fail to fill. If varicosities of the lower leg are present we do not ligate the saphenous vein but carefully inject the varicosities in repeated sessions apply elastic support maintain hygiene and await effect upon the ulcer. In a fair number of cases healing will take place. If not excision and graft and in rare instances sympathectomy must be considered.

4 The dye may fail to enter the deep veins of the lower leg but spread through superficial varicosities along the calf muscles and above the knee be distributed between the saphenous and the femoral vein for ascent into the great veins of the pelvis. One is impressed repeatedly by the amount of vasospasm in such cases. Ulceration is less common than troublesome edema. The patients commonly state that they can wear a bandage with moderate comfort and reduction but not control of the edema. The foot is usually moist and clammy. Our policy is to do a sympathectomy if a good response follows a diagnostic paralumbic sympathetic block and try ambulatory treatment with elastic support. If the patient can walk comfortably and work satisfactorily we are inclined not to inject superficial varicosities for fear of troublesome ascending thromboses. If he is somewhat improved but edema persists and there are large lower leg varicosities these are injected locally using very small quantities of sclerosing media and often before so doing the long saphenous vein is divided below the knee.

5 The dye may be distributed more or less equally all the way up the leg and thigh between the superficial and nontortuous deep system but show large coils of varicosities around and under an ulcer area. This is suggestive of old thrombophlebitis.

with recanalization. Homans has suggested that a recanalized femoral vein is in effect a varicose vein subjected to reflux flow in the same manner as a long saphenous vein with incompetent valves that it may stimulate vasospasm and that perhaps it should be divided in the superficial femoral area. While Homans' idea seems sound in theory, the danger of increased edema and disability after sacrifice of a femoral vein that retains even a semblance of function has restrained us from testing this idea in practice. However, we are convinced that the communicating veins under and about an ulcer bed must be obliterated. This is done by excision of the ulcer and underlying fascia and division of the communicating veins beneath the fascia. Several days later when healthy granulations have formed a thick Thiersch graft is applied. In addition the operation of Linton³ occasionally proves necessary for widespread communicating channels in the lower leg.

COMMENT

If under any of these circumstances the involved leg is moist, cool and vasospastic, a paravertebral lumbar block is done to determine what effect the release of spasm will have upon the surface temperature and the sweating. In a few cases we have tried with repeated lumbar sympathetic block to learn whether discontinuous interruption of vasospastic impulses might permanently break the reflux arc. As anticipated, the beneficial effects have been transitory and have but confirmed our belief that permanent interruption of the sympathetic pathway is desirable in chronic thrombophlebitis with complicating vasospasm. Two major objectives are accomplished. First, vasospasm is reduced and tissue oxygenation is improved. Secondly, the clumsy, cool extremity is converted into a dry, warm extremity and control of a previously intractable fungous infection is effected. Sympathectomy seems radical therapy for epidermophytosis but its control often prevents recurrent ulceration and makes permanent healing possible. Needless to say, it is employed only when simpler measures will not suffice. An ulcer which cannot be healed readily by local measures while the patient is ambulatory, rarely can be kept healed when accomplished by bed rest and hygiene alone. Nearly every varicose or thrombophlebotic ulcer can be healed by bed rest, elevation and proper hygiene, but most of them will break down again.

under ambulatory conditions. The few exceptions may be attributed to education of the patient in meticulous hygiene during his bed rest period. Therefore in most instances more intensive therapy is required.

SUMMARY

It is emphasized that thrombophlebitis is a serious disabling disease that constant vigilance and care will reduce its post-operative incidence that prompt therapy in the acute period will decrease the number of late distressing sequelae. The rationale and methods of therapy for acute and chronic thrombophlebitis as used at the Liley Clinic are outlined and discussed.

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LABORATORY AIDS IN THE DIAGNOSIS OF ENDOCRINE TUMORS

H J PERKIN

THE laboratory offers assistance to the clinician by adding confirmatory evidence of the presence of a tumorous growth in some of the endocrine glands. In the majority of instances in which the laboratory tests establish the provisional diagnosis an excessive or diminished secretion from the affected gland usually exists. This secretion may be the normal product of the endocrine gland or a related specific factor. The available procedures either biologic or chemical for determining these endocrine factors are not too difficult to be undertaken by the clinical laboratory.

The purpose of the present discussion is to outline briefly some of the laboratory procedures employed at the Lahey Clinic which have been found of value in confirming the presence of tumors involving the endocrine glands.

Pituitary—Aberrant growths of the anterior pituitary gland may be associated with either excessive or diminished secretion of pituitary products. If the amount of secretion is excessive an increase over the normal amount of gonadotropic hormone (prolin A) is found in the urine of both males and females. The *prolin A in the urine* may be demonstrated in the following manner. An equivalent of 35 cc of urine (when the twenty-four hour excretion approximates 1 liter) is shaken with an equal volume of ether. The extracted urine is then mixed with 5 volumes of 95 per cent ethyl alcohol. The precipitate which forms is recovered, dried and taken up in 2 cc of normal saline. This extract is filtered. The filtrate is injected by divided doses into an 8 gm immature female mouse over a period of forty-eight hours. Vaginal smears from the mouse are taken on the third, fourth and fifth days. The smears are stained with thionin or any suitable stain. Evidence of estrus in the smears indicates an excessive amount of follicle stimulating hormone (prolin A).

in the original urine sample.⁴ The reaction should be negative in normal males and normal menstruating females. It should be noted that primary ovarian failure (menopause) may be a complicating factor in that a positive reaction is invariably found in such cases.

In addition to the direct evidence of hyperpituitarism previously mentioned certain other glands may be involved secondarily. In this connection an excess secretion of thyrotropic hormone may be present in hyperpituitarism resulting from a pituitary tumor. This may result in a secondary hyperthyroidism which may be detected by the estimation of the iodine of the blood⁵ or the rate of oxygen consumption.

In patients with a pituitary tumor of such a nature that the normal secretion of the gland is suppressed the estimation of the gonadotropic hormone in the urine would appear to be of doubtful value. A diagnosis of hypopituitarism in such cases is better established by estimating the degree of activity of endocrine glands which are influenced by the pituitary gland. In this connection there is frequently a decrease in the level of sodium in the blood serum. This decrease is presumably attributable to adrenal insufficiency resulting from a deficiency of adrenotropic hormone from the pituitary gland. In this laboratory the method of Butler and Tuttle⁶ has been found satisfactory for the estimation of the serum sodium.

Ureal—Pineal tumors are rare but in 1 case in which an opportunity for study was given appreciable amounts of estrone and prolactin (methods described elsewhere in this paper) were demonstrated in the urine.⁶

Parathyroid—Tumors of the parathyroid gland with an excessive secretion of parathormone are associated with an increase in the level of serum calcium. The method of Clark and Collip⁷ is sufficiently accurate for clinical purposes. When the presence of an absolute elevation in serum calcium cannot be demonstrated the presence of a negative calcium balance should be considered. In such investigations we have employed the methods of Shohl and Pedley¹⁰ for the estimation of calcium in the urine and feces. In attempting to establish the presence of hyperparathyroidism in this manner one should be cognizant of the fact that patients with clinical hyperthyroidism frequently show a marked negative calcium balance.⁹

Thyroid—Tumors of the thyroid either benign or malignant do not lend themselves to a laboratory diagnosis unless an associated hypersecretion either from the tumor itself or the remainder of the thyroid gland is present. In such cases estimation of the blood iodine level or the rate of oxygen consumption are of value.

Pancreas—Tumors of the pancreas (islands of Langerhans) resulting in an excessive secretion of insulin are usually recognized by the attendant symptoms. The associated hypoglycemia is confirmatory evidence. In doubtful instances a six hour sugar tolerance test can be employed in order to secure evidence of hyperinsulinism.

Adrenal—Quantitative estimation of the androgens in urine by biologic or chemical assay is now a recognized procedure. In the chemical assay of androgen computation of the beta-17-ketosteroids presumably gives an index of the secretion from the adrenal cortex.¹¹ Such assays have been carried out in this laboratory using the technic described by Talbot and his associates.^{11, 12, 13} However it should be emphasized that the chemical analysis is somewhat complex and the results secured especially with regard to the beta-17-ketosteroid fraction not too well established. The errors are usually such that low results are secured for the so called adrenal fraction.

Ovary—A primary tumor of the ovary does not usually result in sufficient excretion of the sex hormones to produce a positive pregnancy test either in mice or rabbits. On the other hand pregnancy tests should be carried out in order to be certain that a supposedly ovarian tumor is not a pregnancy. Estimation of the estrogens in the urine in excess of normal may be found of value in the diagnosis of some ovarian tumors. A simple method for the assay of urine estrone follows. 200 cc of urine (when the twenty four hour excretion approximates 1 liter) is extracted by shaking with an equal volume of ether. The ether layer is recovered, evaporated to dryness and the residue taken up in 1.5 cc of saline. This extract is injected by divided doses over a twelve hour period into an adult castrated female mouse. Vaginal smears are taken on the mouse at twenty-four, thirty-six and forty-eight hours following the last injection. Evidence of estrus in any of the smears is characterized as a positive reaction.⁴ In menstruating women the reaction should

be negative during the follicular phase of the cycle and positive during the luteal phase. Excess estrogens in the urine during the luteal phase can sometimes be differentiated from excess estrogens due to ovarian tumors or cysts by determining the presence of progesterone (pregnandiol)¹⁴ in the urine.

Prostate—Recent reports in the literature have indicated the value of serum acid phosphatase estimations in the diagnosis of malignant tumors of the prostate gland.⁵ Although our results⁷ on a relatively large series of cases are not as conclusive as those reported nevertheless the test appears to be of value. The method used in this laboratory for the estimation of serum acid phosphatase is as follows: A substrate of sodium beta glycerophosphate (0.5 per cent) and veronal (0.12 per cent in 0.1 N acetic acid) and sufficient concentrated acetic acid (700 to 250 cc per liter) to adjust the pH to 5.0 is employed. The same technical procedure as described by Bodansky¹ is followed except that an incubation period of three hours is allowed. The result is expressed in units, 1 unit being equivalent to the liberation of 1 mg of inorganic phosphorus per hour by 1 cc of serum. Serum acid phosphatase values in excess of 1 unit are confirmatory evidence of a malignant growth involving the prostate gland. At the present time this test appears to be specific.

Testis—It would appear that prolan and estrone estimations are of much greater value in determining the presence of tumors of the testicles than are pregnancy tests. Using the previously mentioned tests the finding of either prolan or estrone in the urine of males suspected of having a testicular tumor is confirmatory evidence of such a pathologic condition.

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ACUTE CONDITIONS WITHIN THE ABDOMEN DIAGNOSIS AND FACTORS OF SAFETY IN TREATMENT

HERBERT D. ADAMS

ACUTE abdominal pain is an interesting and important symptom since it may announce the onset of one of a wide variety of acute conditions. Many diseases of a circulatory, inflammatory or obstructive nature associated with various intra abdominal and some extra abdominal systems may be the cause. Because of the difficulties and ramifications of diagnosis careful consideration of the character and localization of the pain and associated symptoms is more essential than in any other region of the body. The correct diagnosis will be reached with the maximal frequency when every detail of the history and physical findings is fitted carefully into the clinical picture.

In addition certain principles in the selection of treatment must be applied if the patient is to have the best care. On many occasions although as accurate a differential diagnosis as possible is made yet it is not sufficiently accurate to insure an absolutely safe course of treatment. Under these conditions the physician must recognize the diagnostic limitations and formulate certain safety factors and a practical hypothesis of treatment to cover all eventualities and safeguard the patient.

Acute Appendicitis and Simulating Conditions

Acute appendicitis must always be considered since it is well recognized that acute appendicitis can simulate practically every other acute abdominal condition. When the history and physical findings are typical little difficulty in diagnosis is encountered but when the symptoms and physical findings are atypical or even bizarre as is frequently the case the diagnosis may be difficult and lead to the consideration of many other conditions.

A differential diagnosis between acute appendicitis and acute pelvic inflammation is often necessary. In spite of every consideration an accurate differential diagnosis is frequently impossible. Under these conditions a practical principle of safety

and treatment must be applied to avoid overlooking an appendicitis in the pelvis. If the history is typical of appendicitis but the physical findings are consistent with acute pelvic inflammation or vice versa it is best to operate for appendicitis since some of these patients will have infection in this organ.

Acute mesenteric adenitis may simulate appendicitis in every respect. Although in some cases it may be suspected because of poorly localized symptoms and physical signs such a diagnosis cannot be made with any certainty and operation must be advised.

Right sided ureteral calculus will occasionally produce symptoms and physical signs that make a differential diagnosis from appendicitis very difficult. The sudden onset of acute pain, marked involuntary muscle spasm out of proportion to the tenderness, degree of fever or elevation of leukocyte count as compared with the physical signs may suggest a ureteral calculus. Although the urine may show small amounts of blood or pus this cannot be relied upon as a safe differential factor. Ureteral calculus must be ruled out at once by roentgenologic examination, cystoscopy and retrograde catheterization of the ureter. If these procedures cannot be carried out it is safer in these borderline cases to operate for appendicitis.

Acute infection in a low lying gallbladder may likewise be difficult to differentiate from appendicitis. An attack of acute right sided pain with or without a history of a previous attack with localized tenderness and spasm in the right abdomen or at the level of the umbilicus, elevated temperature and leukocyte count all point toward appendicitis or acute cholecystitis. From a purely practical and safe viewpoint further differential diagnosis is unnecessary since exploration is indicated. An appendectomy or cholecystectomy may be performed according to the findings.

Acute Meckel's diverticulum will give a clinical picture similar in most respects to acute appendicitis. The true nature of this inflammatory process is usually not discovered until the obviously necessary exploration is undertaken. However if one is careful in evaluating symptoms one may suspect the true nature of the condition. A Meckel's diverticulum lying as it always does in a bed of small bowel usually very early produces various degrees of small bowel obstruction and a characteristic

difference in the type and localization of the pain. Similarly regional or terminal ileitis usually produces some small bowel symptoms, often large bowel symptoms, and a greater degree of chronicity. Obviously because of the fine differentiation between acute Meckel's diverticulum or *terminal ileitis* and acute appendicitis a large majority of these patients are operated upon with a preoperative diagnosis of acute appendicitis.

Acute involvement of a diverticulum of the sigmoid and the rarer condition of *torsion and partial gangrene of the omentum* produce physical findings that cannot be differentiated from acute appendicitis although in the former a history of bowel symptoms may suggest the proper diagnosis. However in all three conditions the physical findings demand exploration.

Appendicitis with perforation and associated peritonitis may be confused with a *perforated peptic ulcer*, *terminal ileitis with perforation* or *diverticulitis of the sigmoid with perforation*. Since the physical findings in all conditions are those of peritoneal involvement the history may be the only differential factor. Exploration is usually necessary.

Acute Pelvic Conditions

A number of pelvic conditions may produce acute abdominal symptoms. *Acute pelvic inflammation* associated with acute salpingitis is rarely confused with any condition other than *appendicitis*, *acute diverticulitis* (Meckel's or sigmoidal), *regional ileitis* or other *gynecologic conditions*. The differential diagnosis of acute salpingitis and an acute appendicitis in the pelvis has been discussed and similarly the possibility of a diverticulitis or regional ileitis in the pelvis demands exploration.

In many respects an attack of lower abdominal pain similar to an appendicitis with recurring attacks midway between the menstrual periods is suggestive of a *ruptured corpus hemorrhagicum* but in most of these cases exploration must be undertaken to rule out appendicitis. If an accurate diagnosis could be made surgery would be unnecessary except in an occasional case in which intra abdominal hemorrhage is severe. In these rare cases as in *ruptured tubal pregnancy* there are physical signs of widespread peritoneal irritation due to the presence of blood but the extreme toxicity, general reaction and fever associated with bacterial invasion of the peritoneum are absent. In addition,

most cases of ectopic pregnancy have a typical history of some menstrual irregularity followed by intermittent uterine cramps and vaginal bleeding and when rupture occurs, show varying degrees of shock due to the intra abdominal hemorrhage. A patient who complains of a sudden onset of low abdominal and pelvic pain increasing in intensity and associated with a progressive toxicity and a systemic reaction and who has a tender pelvic mass must be operated upon for an *ovarian cyst* or *fibroid with twisted pedicle*, infarction and necrosis.

Acute Conditions in the Biliary Tract and Its Allied Organs

The biliary tract and its allied organs are a common site for acute conditions. The ordinary *hydrops of the gallbladder* due to sudden obstruction of the cystic duct by a gallstone causes severe right upper quadrant pain with characteristic radiation into the back and under the shoulder blade tenderness and spasm in the right upper quadrant of the abdomen but unless progressive infection or gangrene of the gallbladder is present only a low grade systemic reaction is to be expected. However if on a conservative regimen the pain physical findings and systemic reaction increase or fail to improve within forty eight hours the gallbladder should be removed to avoid possible perforation. Severe right upper quadrant or epigastric pain associated with clay colored stools dark urine and icterus indicate a *common duct stone* and operation should be undertaken as soon as the patient can be prepared. If pain in the left abdomen and back and vomiting are present there is probably an associated *subacute pancreatitis* and the common duct should be explored and drained. With severe pain vomiting physical findings of peritonitis and severe toxicity bordering on shock there is probably an *acute hemorrhagic pancreatitis* which should be treated conservatively. The condition may be difficult to differentiate from a *perforated peptic ulcer* and widespread peritonitis but in the latter the liver dullness is usually obliterated by gas beneath the diaphragm. In some cases exploration will be necessary.

Penetrating or Perforated Peptic Ulcer

Penetrating or perforated peptic ulcer with a local walling off of the perforation produces severe epigastric pain tenderness

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In many respects an attack of lower abdominal pain in a woman with recurring attacks in the menstrual periods is suggestive of a *ruptured tubal pregnancy* but in most of these cases exploratory laparotomy is necessary to rule out appendicitis If an accurate diagnosis is made surgery would be unnecessary except in cases in which intra abdominal hemorrhage is seen as in *ruptured tubal pregnancy* there is evidence of widespread peritoneal irritation due to the presence of blood but the extreme toxicity general reaction and the presence of bacteria with bacterial invasion of the peritoneum are all

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Penetrating or perforated peptic ulcer with a local walling off of the perforation produces severe epigastric pain tenderness

and muscle spasm without the systemic reaction toxicity and ultimate shock produced by rapid perforation of a duodenal ulcer on the anterior wall. The latter patients should have an emergency operation and the former should be prepared for a major resection.

Acute Conditions of the Small and Large Bowel

Acute conditions of the small and large bowel are comprised primarily of obstructive and inflammatory lesions. Small bowel obstruction varies in severity of symptoms and seriousness depending on the character of the causative lesions and the level and duration of the obstruction. *Small bowel obstruction* evidenced by severe intermittent crampy pain of the epigastrium or upper abdomen vomiting and visible or audible high pitched peristalsis may be due to a variety of lesions. All such patients should be examined for external evidence of *hernia* (incisional epigastric umbilical inguinal and femoral) and for a possible incarceration or strangulation. An abdominal scar suggests *intra abdominal adhesions volvulus* or even a *foreign body* as a mechanical cause of obstruction. Another mechanical cause is *intussusception* due to a diverticulum or polyp. With a history of long standing attacks of biliary colic a *gallstone* *leus* must also be suspected. These in addition to *inflammatory cicatrizing lesions* such as *tuberculosis* or *regional ileitis* and *tumors* both benign and malignant comprise most of the common lesions producing small bowel obstruction. A careful appraisal of the history may aid in the differential diagnosis and roentgenologic examination is frequently helpful in determining the location and sometimes the character of the lesion. The duration of the symptoms and the general condition of the patient determine the need for study or preparation before exploration.

Among large bowel lesions producing acute abdominal symptoms *acute inflammatory processes* and *obstructing carcinoma* are the most common. Acute symptoms due to inflammatory disease involving the large bowel are frequently associated with the *perforation of ulcerative colitis* or *acute diverticulitis* or *carcinoma*. Obstruction is practically always due to carcinoma rarely to *volvulus* of the sigmoid. Roentgenologic examination and proctoscopy are of value in diagnosis in the less acute phases.

ALLERGY AND THE SURGICAL ABDOMEN

JOHN L. FROMER

THE subject of allergic smooth muscle spasm simulating acute surgical conditions of the abdomen is of great interest to the internist and surgeon and unfortunately it has not received the attention it deserves. The symptoms of allergy may be limited to the gastro intestinal tract and the mechanism involved in such cases has become somewhat clearer in recent years. A clinical picture simulating appendicitis or some other acute abdominal condition may develop due to gastro intestinal hypersensitivity and only too often patients presenting this picture are operated upon under a mistaken diagnosis. Consequently the internist as well as the surgeon should familiarize himself with certain allergic principles that apply to this problem.

OCCURRENCE

Striking clinical manifestations of allergy to foods appear particularly in childhood. There is a tendency for the child to vomit the offending food. He may also develop a distinct aversion to a particular food when he has learned from previous experience that its ingestion is followed by unpleasant symptoms. In many cases the child will intuitively refuse the offending food.

Several different shock organs in the same individual may be hypersensitive to food allergens. Therefore symptoms of gastro intestinal dysfunction may be present as well as symptoms referable to other shock organs such as the skin (eczema and urticaria) or the bronchi (asthma).

MECHANISM

Spasm in the gastro intestinal tract may be associated with wheals and edema in the bowel wall. Changes in the mucosal pattern of the small bowel as revealed by barium roentgenologic examination may represent thickening of the wall of the exu

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the recognition of the limitations of differential diagnosis and of the common tendency of various acute abdominal conditions to simulate each other closely. Under such difficulties differential diagnosis can approach accuracy only by the meticulous analysis of even the most insignificant details of history and physical signs. Even then certain principles of surgical treatment based on a wide margin of safety must be formulated to compensate for the inadequacies of diagnosis.

ground the differential blood count presents an unusual eosinophilia the clinical picture is atypical and previous similar attacks with recovery have occurred. In most cases a diagnostic adrenalin injection has not been tried. Finally operation has not relieved the condition and recurrence of symptoms has followed. When allergy is suspected as it should be if any of the above factors are present useful information may be obtained by inquiring about food or drug idiosyncrasy. One should ascertain whether the patient presents other features of allergy such as bronchial asthma, eczema, urticaria, purpura or joint pains.

SUMMARY

Many patients with an allergic background present signs and symptoms suggestive of an acute surgical abdomen but actually due to an allergic response. Two conditions have been presented which do not require an antecedent or coexisting allergic history, namely serum sickness and black widow spider bite, yet an allergic mechanism adequately accounts for the symptoms seen. In the majority of cases an allergic constitution, an eosinophilia, an atypical story and a response to minimal doses of adrenalin warrant explanation of the symptoms on an allergic basis. It should be understood, however, that it is best to err on the side of surgery in those cases of acute disease of the abdomen in which one cannot find substantial evidence in favor of allergy as an explanation of the condition.

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attributed to an allergy in milk is observed by Kern and Stewart.³ Violent lower abdominal pain may be part of a constitutional reaction resulting from specific treatment of hay fever with pollen extracts. It must be remembered that the smooth muscle of the uterus is capable of violent contraction as a response to the antigen antibody mechanism. A miscarriage may result from this same mechanism.

Serum Sickness

Finally, the problem of acute abdominal pain may be presented in two other interesting allergic conditions. The first is serum sickness which presents the clinical picture of urticaria, fever, joint pains, and not infrequently severe abdominal pain. The onset is usually acute. The condition which originally required serum may have been relieved and the patient discharged. Relief of the abdominal pain as well as the rash usually follows the administration of small doses of adrenalin.

Black Widow Spider Bite

The second anaphylactoid like condition is the syndrome following black widow spider bite. In these cases the generalized urticaria or angioneurotic edema which usually accompanies a shock like condition may be associated with excruciating generalized abdominal pain and a rigid board like abdomen. The strong urge to operate should be curbed and general measures to combat the shock should be instituted.

COMMENT

A brief account of certain conditions having a possible allergic explanation has been presented. These conditions should be considered by the surgeon in the differential diagnostic problems of the acute surgical abdomen. It is important to bear in mind in such cases that something atypical about the history or the sequence of events raises some doubt as to the presence of an organic lesion.

Perhaps the most common allergic condition within the abdomen which confuses the clinician is the intestinal spasm which simulates *appendicitis*. Patients with suspected appendicitis in whom an operation on an anatomically normal appendix has been found have presented in general a similar clinical pattern. The outstanding features are. The patient may have an allergic back-

involvement of the terminal ileum frequently has given rise to pain and tenderness in the right lower quadrant which has made clinical differentiation from acute appendicitis impossible. At operation the terminal loops of small intestine are inflamed and edematous and the mesenteric glands markedly swollen.

Although diarrhea is more predominant in acute ileitis than in acute appendicitis and the tenderness less localized in many cases laparotomy cannot be deferred because appendicitis can not be ruled out.

In cases in which operation is performed the common sequence of events is the formation within a few days or a few weeks of a *fecal fistula* arising in the terminal ileum and leading out through the operative wound. These fistulas are chronic and show little tendency to heal spontaneously.

In both the operated and nonoperated cases the symptoms of abdominal cramps and diarrhea persist. Diarrhea is not a constant feature but is present in a large majority of cases and in any case of chronic diarrhea small intestinal disease should be considered as a possible causative factor.

Excessive *flatulence* is another prominent symptom in many cases.

Nutritional disturbances frequently develop. Since the abdominal pain is aggravated by eating patients restrict their food intake and the increased motility and small intestinal diarrhea result in impaired absorption. Consequently weight loss, anemia, hypoproteinemia and vitamin deficiency are common particularly in long standing cases.

A diagnostic study of a patient with these symptoms includes physical, proctoscopic and microscopic examinations, cultures of the stools and roentgenologic examination of the gastrointestinal tract with special attention to the small intestine.

In the early stages of the disease the *physical examination* may be negative except for poorly localized abdominal tenderness, weight loss and anemia.

The *proctoscopic examination* is done chiefly to rule out ulcerative colitis or other colonic disease. In ileitis the rectal mucosa may be slightly inflamed as a result of the diarrhea but is not edematous, hemorrhagic or ulcerated.

The stools are liquid but usually contain no gross pus or blood. Since at this stage mucosal ulceration generally is present in

THE DIAGNOSIS OF REGIONAL ILEITIS

(Chronic Idiopathic Ulcerative Enteritis)

EVERETT D. KIEFER

THE small intestine is a relatively new field in gastro intestinal diagnosis and only in recent years has ileitis been established as a clinical entity. Consequently the symptoms, physical signs, laboratory and roentgenologic findings which lead to a diagnosis of regional ileitis are not familiar to every physician.

The first designation of this disease, terminal ileitis, was discarded for regional ileitis when it was recognized that one or more upper segments of the ileum might be involved while the terminal portion remained normal.

As more was learned about this condition it was apparent that it was an inflammatory disease of the mucosa of the small intestine including both the jejunum and the ileum, leading to ulceration of the mucosa, mesenteric lymphadenopathy and eventually marked fibrosis and cicatrizing deformity of the intestinal wall. The complications include obstruction, perforation, internal and external fistulas and marked disturbances in absorption. The etiologic factor remains unknown but it is generally accepted that the tubercle bacillus is not responsible.

A more suitable term therefore is *chronic idiopathic ulcerative enteritis*. Since the pathologist usually sees the disease in its more chronic form he often refers to it as chronic cicatrizing enteritis.

CHARACTERISTICS

Obviously the clinical picture of regional ileitis may vary widely according to the stage of the disease. It is predominantly a disease of young adults. The onset may be insidious but is often acute. The symptoms of the early stages of the disease are the result of inflammation, edema and irritation of the small bowel.

Cramplike upper abdominal pain, cramping and diarrhea are the outstanding symptoms. An acute onset associated with in-

Irritability of the small intestine may also be indicated by the segmental distribution of barium throughout the ileum

The signs which are diagnostic of organic changes in the intestinal wall are areas of constant irregularity in outline narrowed lumen changes in the normal mucosal pattern and internal fistulas

Figure 217 shows the typical normal roentgenologic appearance of the small intestine as demonstrated three hours after a



Fig 218—The ileum can be examined by means of a barium enema which is allowed to regurgitate through the ileocecal valve and fill the ileum This roentgenogram shows the appearance of the normal ileum when filled in this way

barium meal The jejunum has been emptied of the bulk of the meal leaving the characteristic snow flake pattern of evenly dispersed flakes of barium of uniform size The ileum occupies the right lower quadrant of the abdomen and presents the typical linked sausage appearance with areas of contraction dividing the barium into fairly equal masses with smooth contours

Figure 219 shows the early changes due to inflammatory disease as definite irregularities of the contour with spiking

the small intestine tests for occult blood in the feces are strongly positive. A microscopic examination should be done to eliminate amebiasis or parasitic infestation and a stool culture is necessary to rule out paratyphoid or bacillary dysentery.

The positive diagnostic signs are obtained by the *roentgenologic examination* of the small intestine. This may be done by taking serial films at hourly intervals for six hours after the barium meal (Fig 217). The terminal ileum also may be vis-

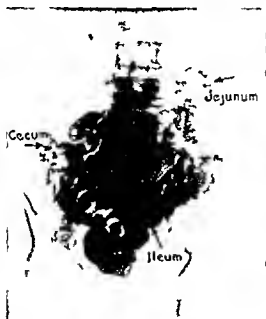


Fig 217—This roentgenogram shows the normal appearance of the small intestine three hours after barium meal. Still flocks of barium in the jejunum give an even, snake-like appearance. The ileum when well filled holds the barium in smooth longitudinal segments interspersed with areas of contraction producing a linked sausage appearance.

ualized satisfactorily by means of a barium enema which flows back through the ileocecal valve (Fig 218). It is also possible to distend the small intestine with barium by means of a duodenal tube introduced through the mouth.

One of the roentgenologic features which is manifested in the early stages of enteritis is increased motility. Hypermotility is more common in the early stages. The barium may transverse the enteric small bowel and in less than an hour enter the cecum while the normal time required is from two to three hours.

pocketing and uneven contractions which divide the barium into masses of markedly varying sizes and shapes. On serial films these irregularities are fairly constant indicating organic changes in the intestinal wall and not merely spasm. Constant rigid narrowing of the lumen over a considerable distance is a characteristic sign.

Changes in the mucosal pattern (Figs 220 and 221) are indicative of inflammatory changes. The mucosal folds normally



Fig 221—This roentgenogram shows the typical irregular contracted loop of ileum (arrow) involved in active ileitis and the dilated loops above this area.

tend to run in an even longitudinal pattern. Marked distortions constitute one of the signs of disease of the mucosa. Small ulcerations are sometimes visible as they penetrate deeply into the wall of the ileum (Fig 219).

Perforation of these ulcerations gives rise to the characteristic fistulas. Fistulous tracts may be single but are often multiple. They may connect the ileum with the colon (Fig 222) with other loops of small intestine or with the bladder, vagina or outside the abdominal wall (Fig 223).



Fig. 219. A late ulcerative stage of ileitis with penetrating ulcerations and marked irregularities of outline of the ileum. Arrows point to ulcers.



Fig. 220.—The arrow points to the characteristic hang in the mucosal pattern of the ileum and the extensive area of marked changes in outline and caliber of the ileum.

tion are absent. A fistula either internal or external is indicative of ileitis rather than new growths or Meckel's diverticulitis.

The differentiation between regional ileitis and *tuberculosis* is the most difficult to make but in the absence of open pulmonary tuberculosis it is fairly safe to assume that the intestinal inflammation is nontuberculous. In intestinal tuberculosis there is a definite tendency to involvement of the cecum as well as the ileum in the granulomatous process (Fig. 226).



Fig. 26—Tuberculous ileocolitis showing involvement of both the terminal ileum and the right colon.

Sharp *foreign bodies* in the intestinal tract may perforate the ileum or cecum and form an inflammatory mass which is almost impossible to differentiate from ileitis unless a history of swallowing a foreign body can be obtained. In some instances a mass thought to be regional ileitis has proved to be a sponge left within the abdomen at a previous appendectomy.

SUMMARY

The diagnosis of ileitis in the early acute inflammatory stage depends upon the clinical evidence of intra-abdominal inflammation with ulceration of the intestinal mucosa and upon roent-

obstruction may be intermittent with the result that gross dilatation of the intestine may not be demonstrable except during the attacks. In such cases serial films taken in asymptomatic periods



Fig. 223.—This roentgenogram of the ileum shows the characteristic features of rigid contraction, the elevated dilatation and the perforation into other loops and into surrounding inflammatory masses.

may show only a single loop of slightly dilated small bowel as the only sign of the obstructive nature of the condition.

DIFFERENTIAL DIAGNOSIS

In the differential diagnosis of chronic regional ileitis the conditions which are to be considered are ileocecal tuberculosis, neoplasm, appendiceal abscess, Meckel's diverticulitis and foreign bodies.

In general the clinical history covering the period of development of the mass will distinguish inflammatory masses arising from *appendicitis*, *Meckel's diverticulitis* and *neoplasm of the ileum* may cause intermittent obstructive symptoms due to intussusception. The roentgenogram may show obstruction but the typical inflammatory changes in the area below the dilata-

REGIONAL ILEITIS SURGICAL MANAGEMENT AND RESULTS OF OPERATION

SAMUEL F. MARSHALL

This discussion of regional ileitis is concerned chiefly with methods of surgical management and with the results obtained in a group of 55 patients seen in the Lahey Clinic over a period of ten years. The diagnosis was established by laparotomy and in all but a few instances was confirmed by pathologic examination. When a specimen could not be submitted to the pathologist the diagnosis was established beyond doubt by the gross appearance of the pathologic lesion at operation and by the history and course of the disease.

My purpose is to present a brief analysis of the end results of cases treated at the Lahey Clinic and to give the operative mortality. I shall make no attempt to compare the end results in these cases with those in other reports because the surgical methods of treatment may be dissimilar and consequently difficult of comparison.

ETIOLOGY

Elsewhere in this symposium Dr. Kieffer has described the symptoms and diagnostic methods which permit recognition of this pathologic lesion. Sufficient to state that the etiologic factors suggested have not proved to be more than theoretical in character and that the pathogenesis has not been definitely established. One of the most persistent explanations advanced is that the lesion is tuberculous but in our experience repeated guinea pig inoculations of diseased tissue have failed to substantiate this contention.

The relationship of regional ileitis, or regional enteritis to *ulcerative colitis* is not clearly established. Some similarity in these two ulcerative lesions of the large and small bowel is suggested by cases of regional ileitis with colon involvement, and vice versa. The pathologic changes in regional enteritis however are those of a productive hyperplastic ulcerative process.

genologic evidence of changes in the normal structure of the small bowel

The diagnosis of chronic regional ileitis is made by demonstrating the typical granulomatous mass in the ileum and the chronic intermittent small intestinal obstruction which usually accompanies this lesion. The roentgenogram is useful in studying the structure of the involved area and in demonstrating the characteristic obstruction and fistulous tracts.

Ulcerative colitis is ruled out by means of roentgenologic and proctoscopic examinations of the rectal and sigmoidal mucosa.

Regional ileitis is occasionally coexistent with ulcerative colitis in which case the characteristic changes are found in both the colon and the ileum.

The establishment of what constitutes the normal roentgenologic appearance of the small intestine and the definition of the signs which denote pathologic changes in the jejunum and ileum have made possible the fairly reliable diagnosis of chronic idiopathic ulcerative enteritis by roentgenologic methods. If the roentgenologic findings are correlated with the clinical observations and with an understanding of the cause of the disease and the morbid process involved, a high degree of accuracy in the diagnosis of regional ileitis is possible.

COMPLICATIONS

Abscess formation is common and is usually confused with appendiceal abscess. *Fistulas* of various types which may communicate with adjacent loops of small bowel sigmoid transverse and ascending colon or with the urinary bladder are frequent. In this group 2 patients had a fistula into the urinary bladder. An external fistula on the anterior abdominal wall which is the most common usually follows one or more previous abdominal operations either appendectomy or drainage of an abscess. In this series of 55 operated cases there were 12 patients with an abdominal wall fistula. Perineal fistulas are not uncommon and we have noted 2 cases.

DIFFERENTIAL DIAGNOSIS

In the early stages of regional ileitis the symptoms may be similar to those of *appendicitis*, and differential diagnosis may be difficult. Should laparotomy be undertaken the terminal ileum should be inspected carefully especially if the appendiceal disease does not parallel clinical findings. Enlarged glands in the adjacent mesentery together with early inflammatory changes in the terminal ileum definitely indicate the true nature of the disease process.

Probably because of this confusion with *appendicitis* 20 patients in this group had had appendectomy elsewhere without alleviation of the abdominal distress. Appendectomy should not be done in the presence of an adjacent regional ileitis and indeed it may result in the development of an abdominal wall fistula as was the case in all 12 of our cases of external abdominal wall fistula. Obviously when a patient has a fecal fistula following appendectomy the possibility of regional ileitis should be considered; this is especially true if the disability is long standing and has not been corrected by repeated attempts at closure of the fistulous tract. In our group 1 young woman had had no less than seven operative attempts to close such a fistula without the true pathologic condition being recognized.

TREATMENT

From the numerous reports in the literature the physician must conclude that surgery is the accepted method of treatment yet there is considerable difference of opinion as to the method of surgery to be applied and the results to be obtained. It is

with granuloma and marked lymphoid infiltration while those of ulcerative colitis are principally destructive in character with marked ulceration. When the initial lesion arises in the terminal ileum cecal involvement is fairly common. Involvement of the ileocecal valve is frequent and in 10 of our cases inflammatory thickening and ulceration involved the cecal wall.

We have also noted involvement of the ascending colon in 2 cases and 1 girl 18 years of age had marked extension to the colon affecting the ascending transverse colon and splenic flexure. In this case the ileocolitis was complicated by obstruction of the ileum by perforation with abscess formation and fistula into the bladder. Surgical management consisted of preliminary ileocolostomy and drainage of the abscess. The affected colon with the involved ileum was resected. The patient made an excellent recovery. Two of our patients with recurrence of the disease also developed acute ulcerative colitis. 1 of these died after operation and another is in good health after ileostomy.

CHARACTERISTICS

Certain characteristics and complications of regional ileitis assist materially in the diagnosis as Dr. Kieffer emphasizes. The disease affects principally young adults though it may occur at any age. Our youngest patient was 16 years of age and our oldest was 69 (Table 1). Forty-six patients (83.6 per cent) were less

TABLE 1
AGE DISTRIBUTION

Age	Number of Cases
10-20	9
21-30	22
31-40	15
41-50	4
51-60	2
61-70	3
Total cases	55

than 40 years of age. Sex distribution was about equal—29 men and 26 women. Other characteristics of the disease are of interest particularly its slow development, chronicity and tendency to perforate and to form abscesses or fistulas. The duration of symptoms varies from six months to as long as eight years as occurred in 1 case though the average duration is a year or longer.

licz type of resection (Figs 227 and 228) By this method we resect the involved bowel together with the involved glands in its adjacent mesentery By decompressing the small bowel which is often obstructed we avoid the danger of leakage or contamination of the abdominal cavity from a primary anastomosis with a resultant peritonitis which accounts for the majority of fatalities following a one stage resection We firmly believe that this method of resection keeps postoperative morbidity and mortality at a minimum

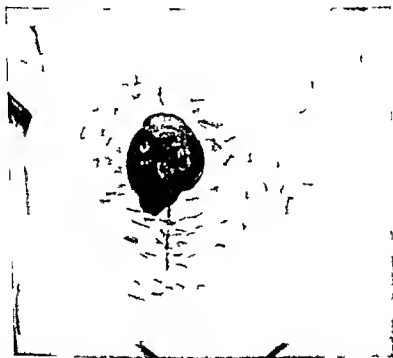


Fig 228—Enterostomy following Mikulicz type of resection for regional ileitis Resection done eight weeks before enterostomy now ready to be closed Note absence of skin irritation

The involvement of adjacent glands is a definite source of recurrence or spread of the disease and at the Clinic we are convinced that one of the most important steps in the operation is their wide extirpation Another factor in recurrence which has been emphasized and reemphasized by Crohn and other workers is the nonrecognition of the characteristic *skip areas* in the bowel Failure to find these areas results in persistence of the disease and failure to alleviate the symptoms Obviously these incompletely treated cases should not be classified as recurrences

Before resection is undertaken *every inch of the intestine should be examined* for any other involved areas. In our opinion as emphasized before the initial lesion should be removed when ever possible. Simple ileocolostomy without removal of the affected bowel usually results in failure to relieve the symptoms and may lead to widespread involvement of other loops of the intestine which would naturally prohibit any further surgical management.

One patient in this group a girl aged 23 years who had had an ileocolostomy five years previously complained of pain in the right lower quadrant associated with diarrhea. She was anemic and undernourished. At operation the terminal ileum beyond the ileocolostomy was edematous hyperemic and greatly thickened. The intestinal lumen was almost occluded and the mucosa destroyed. The terminal ileum beyond the ileocolostomy was resected together with the cecum and ascending colon proximal to the previously established anastomosis. The patient made an immediate recovery, gained 15 pounds in three months and has been well for a year and a half.

Spontaneous remission of the disease probably occurs in a few cases as it evidently did in the 2 cases in which abscesses were drained and in the 4 patients with ileocolostomy only. All of these patients had an acute fulminating disease process which probably had not reached the chronic contracted cicatricial stage and for which resection was considered unwise. Certainly in advanced cases with marked granulomatous changes in the bowel with cicatricial stenosis obstruction and ulceration the only possibility of permanent cure lies in removing the affected segment of bowel. In view of the tendency of the lesion to perforate to form abscesses and fistulas resection should be considered early and is the treatment of choice if the patient's condition permits radical operation.

The *operative mortality* for the 55 patients was 5.5 per cent (3 deaths). The types of operation employed are indicated in Table 7. In thirty-five two stage resections of the Mikulicz type 1 death due to pulmonary embolism occurred eleven days after the first stage. This represents a mortality of 2.8 per cent. In the presence of simple fecal fistula complicating regional ileitis we have not hesitated to employ the two stage Mikulicz resection no deaths have resulted. In the presence of considerable

TABLE 2
TYPE OF OPERATION AND NUMBER OF DEATH

Type of Operation	Number of Cases	Number of Death
Resection with primary anastomosis	1	0
Preliminary ileocolostomy and later resection	4	0
Mikulicz resection	3	1 (embolism)
Ileocolostomy only	5	1
Drainage of abscess only	3	1 (perforation with peritonitis)
Resection of ileum, cecum ascending colon Ileocolostomy done elsewhere five years before	1	0
Total cases	3	3

abdominal wall infection or an intra abdominal abscess it is much safer to perform a preliminary ileocolostomy and drain the abscess. Resection of the affected segment of bowel is done at a later date. This procedure has been carried out in 4 cases. Resection with primary anastomosis is done chiefly when removal of only a segment of small bowel is necessary.

FOLLOW UP RESULTS

When one considers the advanced disease encountered in most of these cases the follow up results are excellent. Although limitations of space preclude a detailed account of each case Table 3 gives the approximate follow up periods on 42 patients.

TABLE 3
RESULTS FOLLOWING OPERATION

Since Operation	Well	Two to Four Liquid Stools Daily No Other Symptoms	Recurrences
5 yrs or more	15	0	0
4 to 5 yrs	6	0	1
3 to 4 yrs	2	1	0
2 to 3 yrs	10	3	2
1 to 2 yrs	4	0	2
Less than 1 yr	5	0	0
Total	42	4	5

Four postoperative deaths three following primary operation in Lahey Clinic (Table 2). One death occurred in case reoperated for recurrent disease. This patient died from perforation of acute ulcerating colitis.

and some indication of how long they apparently have remained in good health

Four patients have complained of diarrhea consisting of two to four loose stools a day however they have gained in weight have carried on gainful employment and have had negative roentgenologic examinations Most writers who have reported series of cases of ileitis have agreed that this diarrhea is based on hypermotility of the bowel and does not indicate recurrence of the disease Extensive resection of the bowel or a sidetracking operation produces the same type of hypermotility and liquid stools

Five patients have had definite recurrent disease Two had a further resection with 1 death resulting from an acute fulminating ulcerative colitis proved by postmortem examination The second patient has now been well for two years except for diarrhea A third patient with recurrence developed acute ulcerative colitis which required ileostomy He is now in fair health and able to work but the ileostomy will be permanent and colectomy will be performed later A fourth patient with recurrence developed extensive enteritis and surgery is neither feasible nor advisable His general condition is fair In the fifth patient with recurrence the disease should be classified as persisting since the extent of involvement precluded removal of all the affected bowel at operation five years previously Symptoms are chiefly those of tenesmus diarrhea and anemia

SUMMARY

A series of 55 operated cases of regional ileitis is reported The operative mortality is 5.5 per cent that is 3 deaths in 55 cases One additional death followed operation for recurrent regional ileitis Five patients have had definite recurrence of their disease a percentage of 9.6

Complete extirpation of the affected bowel is strongly urged whenever possible together with wide removal of involved mesenteric glands We believe that the two stage Mikulicz type of resection has distinct advantages over other types of resection and can be employed in serious cases with low operative hazard

The operative mortality following the Mikulicz type of resection is 2.8 per cent that is 1 death in 35 resections and this resulted from pulmonary embolism

BRONCHIOGENIC CARCINOMA

With Special Reference to the Management of the Bronchial Stump in
Total Pneumonectomy

HERBERT D. ADAMS

THE effective treatment of bronchiogenic carcinoma in keeping with the principles of surgical management of carcinoma in general demands as radical extirpation of the primary lesion as possible and the resection of the regional lymph glands. This means total pneumonectomy and resection of as many of the hilar lymph glands as possible. Successful results in these cases depend chiefly on two factors: first operability, and secondly primary healing of the hilar structures and of the thorax without pleural infection or drainage.

In general operability depends chiefly on early diagnosis and primary healing results only from the proper technical management of the hilar structures, particularly the bronchial stump, the prevention of residual infection by meticulous protection and walling off of the pleura and wound and the judicious use of the sulfonamides.

Unfortunately the low operability in this disease is one of the most disheartening aspects. Like carcinoma of the stomach, significant symptoms tend to develop late, and difficulties in diagnosis tend to prolong further this important time factor. Therefore the medical profession should make a greater effort to educate the public regarding the early symptoms of this disease. It is equally as important for the medical profession not to overlook this diagnosis or to delay proper studies in patients with chronic cough, wheezing, sputum, hemoptysis, pain or atypical pneumonia. Roentgenologic studies interpreted by a competent roentgenologist, bronchoscopy and consultation with thoracic specialists on abnormal findings will go far in increasing the operability.

The technical aspects of total pneumonectomy involve chiefly a properly administered intratracheal anesthetic, the prevention

of shock by the routine use of transfusions during operation adequate exposure prevention of contamination of the wound and pleura by careful walling off with cellophane lined gauze packs in conjunction with the use of the sulfonamides both locally and systemically and finally the effective management of the hilar structures. Careful individual ligation of the hilar vessels with silk ligatures reinforced with stitch ligatures will control the blood supply to the lungs in an effective and safe manner.

The management of the bronchial stump in total pneumonectomy however is still an inadequately solved technical problem as is evident by the variety of methods advocated and the continued high incidence of bronchial fistula in spite of these improved methods. The importance of obtaining primary healing and closure of the bronchus cannot be overemphasized. Upon it depends a relatively easy convalescence and immediate rehabilitation of the patient for the time he remains free of the carcinoma as compared with a prolonged disability out of proportion to his life expectancy plus a series of secondary operations ranging from thoracotomy and drainage to extensive thoracoplasty to close the residual empyema cavity and the bronchial fistula. The latter is dependent of course upon whether he survives the serious initial effect when the fistula develops with the attendant imminent dangers of pneumonia in the remaining lung or death from sudden widespread pyothorax on the operative side. Only immediate and adequate drainage can prevent a high mortality from this serious complication. Then there follows an uncertain period in overcoming the acute phase of the infection and finally the chronic stage with the essential secondary operations to obliterate the chronic empyema cavity and close the fistula. The high mortality and prolonged morbidity can be prevented and depend therefore on one of the most important technical aspects of total pneumonectomy that is the method of closure of the bronchial stump.

The usual accepted method is anteroposterior closure of the end of the stump with simple interrupted silk sutures reinforced by through and through mattress sutures in one or more rows placed proximal to the end row. This has not proved entirely satisfactory and various methods are now used to reinforce the stump such as turning down a pleural flap or using a free lung

graft to cover it. These methods have not entirely solved this problem and it is for this reason that the following method which has given excellent results is recommended.

TECHNIC

Delayed healing and bronchial fistula are the result of either impaired blood supply, infection or persistent malignancy in the stump. It has been shown that healing and solid closure take place at the very end of the stump. Therefore the rows of mattress sutures placed proximal to the end fail to produce perma-

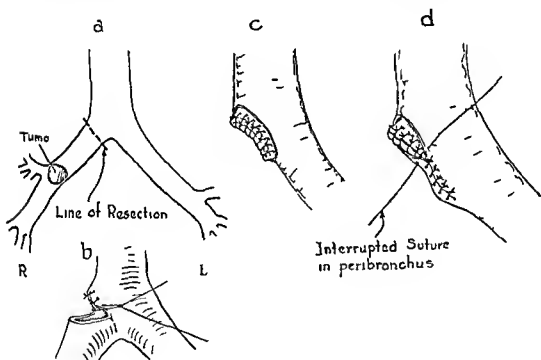


Fig 229

nent obliteration or healing at this level and in addition probably diminish the blood supply to the end where union must take place. For the same reason clamping the bronchial stump before suturing is not recommended. A clamp is placed distal to the point of division to prevent spillage from the specimen during resection. The anesthetist should be warned to obtain a deeper level of anesthesia. Instead of cutting the bronchus completely it is first cut across a little at a time, closing the stump with interrupted sutures as fast as it is cut across (Fig 229 b).

A routine high amputation within 1 cm. or so of the carina

(Fig 229 *a*) is done in this way and the end closed antero posteriorly with a single row of carefully placed No 9 silk sutures (Fig 229 *c*) The *peribronchial* tissues at this level are much thicker and strong enough to support adequately a second row of silk sutures to buttress these tissues over the stump (Fig 229 *d*) To obtain an unobstructed exposure of the bronchus at this high level of section it is necessary to ligate and divide the azygos vein on the right side (Fig 230 *a*) and to mobilize and retract the vagus nerve on the left side (Fig 230 *b*) The

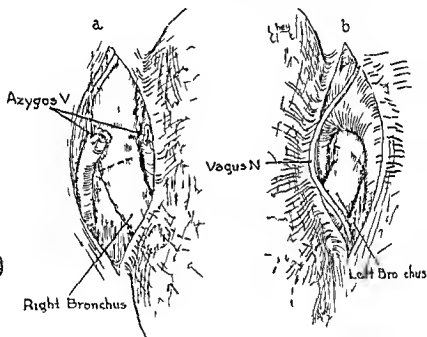


Fig 230

pleura is then closed over the stump and the other hilar structures

In my last 5 consecutive cases I have used this technique with excellent results These cases are presented briefly to show the rapid primary healing of the thorax and freedom from complications

REPORT OF CASES

CASE I—A 44 year old clerk gave a history of cough sputum pain in the chest and weight loss of a year's duration Roentgeno

logic examination showed an atelectasis of the left lower lobe. Bronchoscopy showed narrowing of the main stem bronchus. The left lower lobe showed granulation tissue on the posterior wall which on biopsy was reported as epidermoid carcinoma. After careful preparation including a proper blood level of sulfathiazole a total pneumonectomy with resection of the hilar glands was done. His thorax healed by first intention and following an uneventful convalescence he was discharged from the hospital on the eighteenth postoperative day in good condition. The pathologic report was epidermoid carcinoma grade 3 with metastasis to one node and chronic pneumonitis.

CASE II—A 67 year old plumber gave a history of chronic cough sputum hemoptysis weakness and weight loss of a year's duration. Roentgenologic examination showed an atelectasis of the right lower and middle lobes. Bronchoscopy showed a tumor mass in the right main stem bronchus biopsy of which revealed an epidermoid carcinoma. After careful general preparation including the systemic administration of sulfathiazole a total pneumonectomy with resection of the hilar glands was done. His thorax healed by primary intention and following an uneventful convalescence he was discharged from the hospital on the twentieth day in good condition. The final pathologic report was epidermoid carcinoma grade 2 with negative nodes.

CASE III—A 59 year old salesman gave a history of cough sputum hemoptysis dyspnea intermittent fever and weight loss of six months duration. Roentgenologic examination showed an atelectasis and consolidation of the right lower and middle lobes. Bronchoscopy showed a tumor mass occluding the right lower lobe bronchus and biopsy revealed a carcinoma simplex. After careful preparation and administration of sulfadiazine a total pneumonectomy with resection of the hilar glands was done. Following this he made an uneventful convalescence. The thorax healed by first intention and without difficulty in this respect although his stay in the hospital was prolonged to four weeks due to difficulties with asthma and renal function. However he was discharged in good condition.

CASE IV—A 48 year old farmer gave a history of an atypical pneumonia six months before admission followed by a chronic cough sputum hemoptysis and weight loss. Roentgenologic examination showed atelectasis of the left upper lobe. Bronchoscopy showed the bronchus stenosed and angulated and it was impossible to take a biopsy specimen. Lipiodol injection showed the upper lobe bronchus to be occluded. After careful preparation and the administration of sulfathiazole a total pneumonectomy with resection of the

glands of the hilus was done. He had an uneventful convalescence and his thorax healed by first intention. The final pathologic report was epidermoid carcinoma grade 3 with glandular involvement. Three weeks following operation he was discharged from the hospital in excellent condition.

CASE V—A 57 year old metal buffer gave a two years history of cough, sputum, wheeze and weight loss. Roentgenograms showed a large rounded mass filling the right lower lung fields. On bronchoscopic examination no intrabronchial tumor was visible. No biopsy specimen was taken. After careful general preparation and sulfadiazine a total pneumonectomy with high section of the bronchus and closure by the described method was done. The chest healed in one week and the patient was discharged from the hospital in three weeks. The pathologic report was epidermoid carcinoma with extensive necrosis.

COMMENT

The previously described method is recommended because it fulfills the following important considerations:

- 1 The *most radical operation possible* can be done with reference to the carcinoma which frequently extends especially in the membranous aspect of the bronchus considerably farther proximally than can be observed grossly.

- 2 The *peribronchial and hilar glands* including those important ones at the bifurcation of the trachea can be resected.

- 3 The *bronchial tissues* at this level show less reaction than those closer to the obstructing lesion, less edema and less infection. Therefore closure is in more healthy tissues and with better chance of primary healing.

- 4 The *peribronchial tissues* at this level constitute a distinct structure that can be strongly buttressed over the stump.

- 5 During the postoperative stage there should be less accumulation and stasis of secretion and infection than in the longer stump.

- 6 Theoretically at least there is less possibility of abnormally high pressure developing on respiration and particularly on coughing than with the longer stump.

For these reasons a *routine high section of the bronchus almost flush with the carina* is recommended, closing the stump with a single row of simple silk sutures and buttressing the end with the strong peribronchial tissues which are present at this level.

AMINO ACID THERAPY IN THE HYPOPROTEINEMIC SURGICAL PATIENT

JAMES A. EVANS and EARL J. BOEHME

In the preoperative and postoperative care of the hypoproteinemic patient it is now desirable and practical to pay as much attention to the serum protein level as to the state of hydration and electrolytic balance. Low levels of plasma protein lower the effective osmotic pressure of the plasma and thus may precipitate edema. This is especially true if too much sodium ion is given the patient in the form of normal saline intravenously.¹

Causes of Chronic Hypoproteinemia

The causes of protein depletion fall into two main groups: first, insufficient protein supply, and secondly, inability of the body to utilize amino acid 'building stones' to synthesize body proteins.

In the first group the diet may be deficient in protein or there may be faulty protein digestion or insufficient absorption. Increased protein loss may result from chronic suppuration, intestinal obstruction, ascites, pleural effusion, burns, trauma, hemorrhage, nephrosis, and jejunal fistula. Hypoproteinemia resulting from inability of the liver to synthesize plasma proteins includes those diseases in which there is inadequate liver function. Cirrhosis of the liver and probably nephrosis cause inadequate synthesis of plasma protein. In this last group the use of amino acid therapy is less spectacular than in the group resulting from inadequate protein intake or abnormal loss. In nephrosis, for instance, it is usually impossible to increase the serum protein level though diuresis is accomplished occasionally, as Thorn has suggested, by an increased supply of urea and an increased potassium intake, increased renal blood flow, and the acid ash effect of a high protein diet.

Manifestations

In this paper we are dealing with chronic states of low plasma protein in contradistinction to acute hypoproteinemia from hemorrhage and associated surgical shock. These chronic states of low plasma protein manifest disturbances of a more occult nature: (1) predisposition to edema if too much sodium ion and water are administered to correct dehydration; (2) delay in wound healing; (3) edema of anastomotic stomas resulting in obstruction and distention with loss of more proteins and loss of water and electrolytes in patients requiring Wangenstein suction; (4) increased endogenous tissue metabolism with a negative nitrogen balance as in hyperthyroidism; and (5) interference with the production of hormones as in anorexia nervosa. Since immune bodies are concerned with the globulin fraction of the blood serum, it is very likely that protein starvation results in a lower titer of immune bodies. Adequate proteins are also necessary for the synthesis of the body enzymes.

Administration of Amino Acids

Amino acids either orally or intravenously help restore the depleted protein reserve of the body as well as elevate the serum protein level. For oral administration we add to the daily food ration an amino acid preparation made by the enzymatic hydrolysis of casein*. To this product the manufacturer has added tryptophan. Three ounces in tomato juice is palatable and furnishes the equivalent of 75 gm. of extra protein daily. This is the cheapest product available.

For moderately severe cases of hypoproteinemia in which intravenous fluids such as saline and glucose are also required we have added daily 200 cc. of a 15 per cent solution of amino acid prepared from the acid hydrolysis of casein†. This provides 30 gm. of amino acid in addition to that taken by mouth. For patients with severe hypoproteinemia who can take little or no food by mouth the following intravenous feeding is given every twenty-four hours by a cannula tied in the leg. Such intravenous feedings may be carried out as long as a week at a time.

Generously supplied by Mead Johnson and Company. Amgen unit made available on the market.

† Generously supplied by Frederick Stear and Company as intravenous amino acid solution unit made available on the market.

300 cc 15 per cent amino acid in 3 000 cc saline unless the blood chlorides are normal when the amount of saline is reduced to only 1 000 cc and the glucose raised proportionately in distilled water

300 cc 15 per cent amino acid in 3 000 cc 5 per cent glucose in distilled water

100 mg cevitamic acid

50 mg thiamine chloride

2 cc vitamin B complex intramuscularly

Amino acid 90 gm 374 calories

Carbohydrate 150-250 gm 600-1 000 calories

NaCl 9-27 gm

Water 6 000 cc

Great care is taken to prevent the solution from flowing faster than 1 000 cc an hour. If the rate exceeds 100 cc of amino acid solution an hour the patient is likely to experience flushing and even nausea and vomiting. In our experience these reactions were met less frequently with the acid than with the enzymatic hydrolysate and though the former is more expensive we have lately adopted this product for intravenous use.

Results

Figure 231 shows the moderate though unspectacular improvement resulting from amino acid therapy in the nephrotic state of chronic glomerulonephritis. While the serum protein rose slightly it did not reach normal. Urinary output was not affected and diuresis was obtained only after giving 50 per cent glucose intravenously. Following this there was also weight loss and reduction of edema. Simultaneous studies showed a negative nitrogenous balance.

Figure 232 demonstrates the results of amino acid therapy in a case of edema resulting from too much sodium ion in the presence of hypoproteinemia. The small urinary output at the beginning of this observation demonstrates the attempt of the body to conserve fluid because of dehydration in spite of the edema. Two hundred and fifty cubic centimeters of plasma which actually provide only 37.5 gm of protein produced no diuresis until the serum protein began to rise under the influence of a large amino acid intake. Six days of intravenous amino acid administration and glucose feedings was followed by a marked diuresis, a rise of the serum protein level to almost normal and a reduction of edema. Death followed a long febrile course after exploration of the brain stem through a cervical

lumpectomy and discovery of a large aneurysm of the vertebral artery

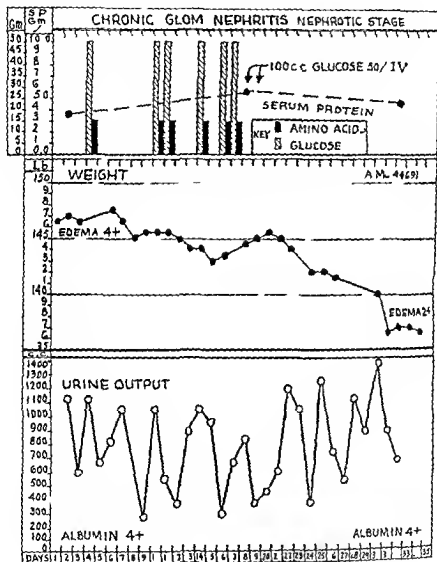
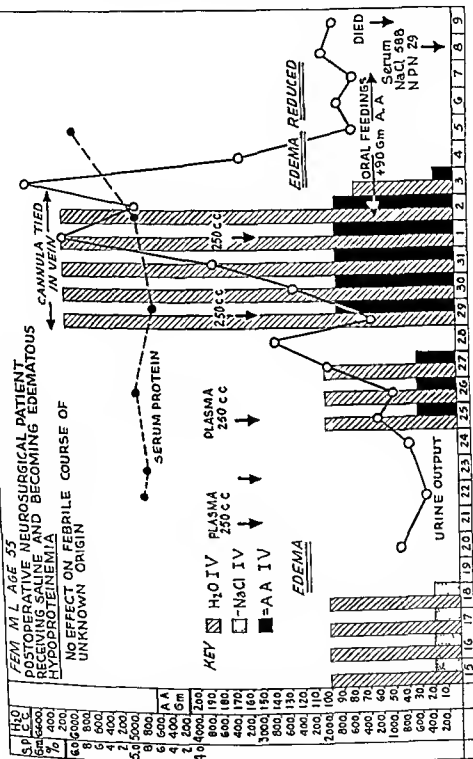


Fig 231

The patient whose chart is shown in Fig 233 entered the hospital in a hyperthyroid crisis complicated by acute brominism with a blood bromide level of 200 mg for each 100 cc



She was dehydrated, cachectic and delirious. After two days of glucose and sodium chloride intravenously a cannula was tied

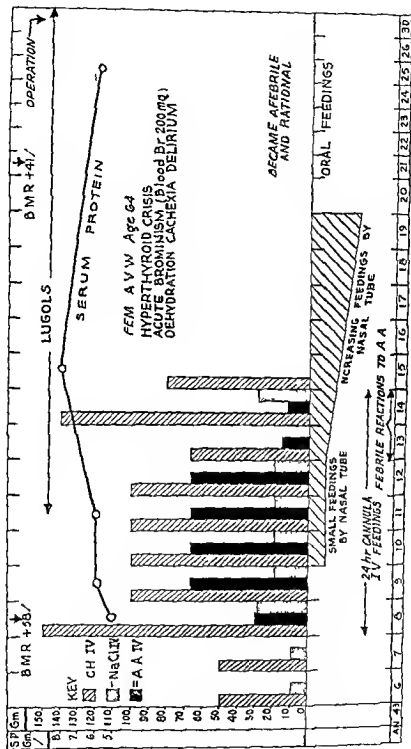


Fig 233

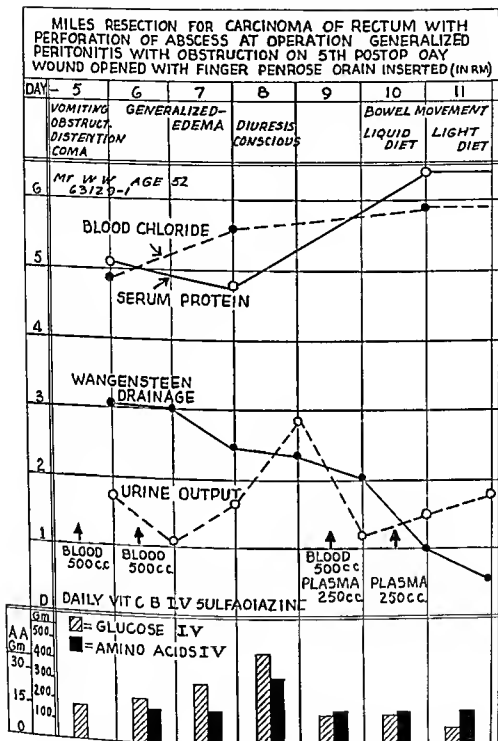


Fig 234

in her vein and for seven days she received continuous intra venous feedings of glucose amino acid and salt. The serum pro

tein rose to normal. Gradually the stomach tolerated larger feedings by nasal tube until finally intravenous feedings were no longer necessary. She became afebrile and rational and on the twenty fourth day after admission a hemithyroidectomy was performed successfully. This case illustrates the successful nutritional support of a patient whose endogenous metabolism was rapidly destroying tissue protein while oral intake was grossly inadequate.

Figure 234 illustrates nutritional support by amino acid solution and glucose intravenously in a patient with obstruction and general peritonitis. Following a Miles resection for carcinoma of the rectum with perforation of an abscess at operation generalized peritonitis and obstruction developed on the fifth postoperative day. The wound was opened with the finger and a Penrose drain inserted. On the sixth postoperative day amino acid and glucose feedings were started. The patient was given whole blood transfusions on the fifth, sixth and ninth postoperative days. Two hundred and fifty cubic centimeters of plasma were given on the ninth and tenth postoperative days. He also received daily injections of vitamin C, vitamin B complex and intravenous sulfadiazine. The blood chlorides rose rapidly to a normal level. Serum protein reached normal by the tenth postoperative day at which time the patient was taking food by mouth. The urinary output reflected the correction of dehydration. The most remarkable effect was the rapid diminution of Wangenstein drainage. The patient had generalized edema which disappeared with diuresis and correction of the serum protein level.

The observation by Perera and Berliner⁴ on the variation of serum protein levels taken when the patient was lying and standing is not relevant in these cases because the serum protein levels were all determined on bed patients. However it is true that part of the serum protein rise in these cases might be attributed to hemoconcentration brought on by massive diuresis. On the other hand Elmn¹ and other workers in this field have proved by hematocrit studies that hemoconcentration studies cannot account entirely for the rise in serum protein. It must also be realized that correction of thyroid intoxication, subsidence of infection, high fluid intake and the nourishment these patients could take by mouth have also played a part in

restoration of electrolytic balance and resultant clinical improvement and diuresis

CONCLUSIONS

- 1 A better balanced regimen for the hypoproteinemic surgical patient can now be given preoperatively and postoperatively with the intravenous use of amino acid solution
- 2 Amino acid solution intravenously helps to correct a low serum protein level in the surgical patient with hypoproteinemia
- 3 Restoration of the proper serum protein level aids diuresis and helps to restore the proper electrolytic balance. Secondary effects are reduction of edema of the postoperative stoma, reduction of Wangenstein drainage and correction of dehydration
- 4 When administered with proper precautions and a controlled rate of injection untoward reactions are rare

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PRIMARY STERILE PYURIA

EARL E. EWERT and HOWARD A. HOFFMAN

PATIENTS with urinary tract infections now are being treated by the physician in general practice more successfully than ever before and since many of these patients have simple uncomplicated conditions nothing more is heard from them. The recent complete literature on this topic and the better understanding of sulfonamide therapy have given most physicians the necessary knowledge and ability to handle these common urinary tract infections.

We wish however to call attention to a urinary tract infection which is caused neither by the common organisms producing pyuria nor by the tubercle bacillus. It seems to be a separate disease although the offending organism is not yet known. This is a true sterile pyuria or what we choose to call at the present time primary sterile pyuria. Scandinavian investigators called attention to the possibility of this condition as early as 1909 but little further research was done until 1921 when Soderland came to regard it as a clinical entity. The lack of definitive laboratory procedures in the early investigators' protocols led to some doubt concerning their conclusions; however their findings were substantiated when cultural and animal tests were devised and improved.

ETIOLOGY

Much of the concern of early debate and experimentation on amicrobial pyuria continues. Suggestions have run the gamut of staphylococcal, uncommon strains of streptococcal and even parasitic agents. These have largely been discredited and the cause of this primary form of sterile pyuria has not yet been determined definitely. However the present day trend would indicate that it is due to a filtrable virus.

The importance of determining the causative organism in any urinary tract infection cannot be overemphasized. When one

realizes the number of times nephrectomy has been carried out for alleged tuberculosis and later found to be unnecessary the importance of thorough understanding of the symptoms and differential diagnosis of primary sterile pyuria is obvious in spite of its relative infrequency

SYMPTOMS

All observers agree that the manifestations of cystitis dominate the clinical picture. The symptoms may be acute or insidious in onset but once established pursue a chronic course of from one month to several years unless appropriately treated. The disease seems to attack young adult males though cases are reported in older men and in females.

The patient presents himself complaining of severe pain on urination with marked urgency, terminal spasm and frequently terminal macroscopic hematuria. In our cases frequency of urination both diurnal and nocturnal just as in tuberculosis was prominent. The urine is uniformly rich in pus but the smears, cultures and guinea pig tests are always negative. Hematuria either macroscopic or microscopic is a constant feature. Albumin and frequently hyaline casts may be found. On cystoscopic examination one is impressed with the marked decrease in bladder capacity and the characteristic diffuse inflammatory reaction of the mucosa. Superficial bleeding ulcers and much purulent exudate are distributed throughout the bladder. At times areas of edema are seen about the ureteral orifices but never infiltration. Upon ureteral catheterization pus cells may be obtained from either or both sides. Kidney function is never disturbed. Pyelography may reveal an entirely normal upper genito urinary tract or only a mild degree of dilatation of the pelves and ureters.

DIAGNOSIS

After completing the history and physical examination a sterile urine specimen is subjected to sediment study, Gram stain and culture. Intravenous pyelography is followed by a simple cystoscopic examination. We realize that this is not always possible and that examination may have to be limited to a Gram stain of the catheter specimen and roentgenologic examination of the kidneys, ureters and bladder.

When one is confronted with urinary tract infection with much pus in which no organisms are demonstrable either by Gram stain or by ordinary cultural methods the natural inclination is to regard the condition as tuberculous. It is generally appreciated that the term sterile pyuria usually means tuberculosis and in most instances this is correct. However if one will bear in mind the possibility of a nontuberculous sterile pyuria prolonged fruitless investigation may be avoided. When pus is found in the urine and Gram stain and culture are negative tuberculosis should be ruled out. If repeated and careful smears from the bladder and kidney urine fail to reveal tubercle bacilli and several sets of guinea pigs have been inoculated and proved negative and if destructive lesions in the upper genitourinary tract are absent it would be well to consider the possibility of a primary sterile pyuria. Intravenous arsenical preparations are attended by such dramatic improvement, often within twenty-four hours that their administration may be a further therapeutic test.

The case histories of the following 2 patients will illustrate the diagnostic difficulties and study necessary at times to disclose the true nature of the offending infection.

REPORT OF CASES

CASE 1—This patient was a 49-year-old man who eight months before registering at the Lahey Clinic complained of a purulent urethral discharge which lasted two to three days and was then followed by urgency and frequency both day and night. There was no history of sexual exposure at any time. His home physician found pus in the urine. Because of the severity of the symptom he was hospitalized for one month during which time bladder irrigations were carried out and sulfanilamide and sulfapyridine were given by mouth. The only finding in the urinary tract was a few coccoid organisms. On this therapy his acute symptoms improved but he continued to have trouble with nocturia. Ten days before presenting himself for examination at the Clinic he had a recurrence of frequency this time with burning on urination and because of this more intensive investigation was deemed necessary.

The patient was well tanned and appeared healthy. The entire physical examination was essentially normal. His prostate gland was normal in size and the smear showed a grade 2 pus content. A second glass urine specimen showed a very slight trace of albumin, no sugar and 25 to 30 leukocytes. No bacteria were seen on Gram stain and

no growth was obtained on urine culture. Three acid fast stains on successive urine specimens were negative. Three sets of guinea pigs were later reported as showing no evidence of tuberculosis.

The patient was admitted to the hospital where cystoscopic examination revealed a generalized inflammatory reaction. Specimens of urine from each kidney were obtained for study. The smear showed no organisms and cultures showed no growth. Bilateral pyeloureterograms disclosed the upper genito-urinary tract to be normal. Functional studies were normal. The hemoglobin was 92 per cent, erythrocytes 4,780,000 and leukocytes 9,000. The laboratory examinations gave no diagnostic clue. The blood Widal and agglutination tests for undulant fever and dysentery fever were negative.

The patient was discharged on sulfathiazole therapy while we awaited the report of the guinea pig examination. On his return one month later he still showed gross pus in the urine. Cultures were sterile and no organisms could be demonstrated either by Gram stain or acid fast stain. In view of the possibility of a true amicrobial infection of the urinary tract we decided to give him neoarsphenamine. Accordingly he was given 0.15 gm. of neoarsphenamine intravenously. In forty-eight hours he volunteered the information that he thought he was voiding less often. Grossly we thought the pus content was less although we were not sure. Three days later he was given 0.3 gm. and the urine in twenty-four hours improved from cloudy to just hazy. Three days later 0.45 gm. was given and the urine became microscopically clear in another twenty-four hours. Before he left the hospital he was given five injections in all, the last three of 0.45 gm. and these at four-day intervals. He has been seen intermittently in the last year and his urine has shown no organisms on Gram stain, a sterile culture and an entirely negative sediment. He is completely free from symptoms. Prostatic examination still continues to show a minimal grade 1 pus content.

CASE II—This patient was also a man aged 23 years who presented himself complaining of terminal hematuria with clots, terminal pain on urination of two and a half months' duration and a urethral discharge for approximately a year and a half. He complained of urgency, frequency both day and night and felt that he had had cloudy urine intermittently over two and a half years. His urethral discharge had been investigated thoroughly and no specific diagnosis made.

His general physical examination was essentially negative. The urinary sediment contained many red blood cells and a few white blood cells. On Gram stain no organisms were found and a culture of the urine was sterile. The acid fast stain revealed no bacilli. His

blood count showed the hemoglobin to be 105 per cent erythrocytes 5 160 000 and leucocytes 15 800. The blood smear was not unusual the Hinton test was negative. The nonprotein nitrogen was 33 mg per cent. Excretion urograms showed a normal pattern.

The patient was admitted to the hospital where daily sediment examinations showed the urine to be loaded with pus and without tubercle bacilli. Cystoscopic examination revealed generalized inflammation and the bladder wall showed numerous areas with adherent exudate. The ureteral orifices were not unusual and catheters were passed up and specimens obtained from both sides. Bilateral retrograde pyelograms were normal. Guinea pigs inoculated with bladder urine and divided urine showed no tuberculous lesions on autopsy.

The patient was given five injections of neoarsphenamine consisting of 0.15, 0.3 and the last three 0.45 gm. All his symptoms disappeared his last urine sediment was entirely negative.

TREATMENT

When the diagnosis of primary sterile pyuria is made ordinary conservative therapy and local bladder instillations as used for routine treatment of plain cystitis produce almost no improvement. The sulfonamides may slightly reduce the total pus content of the urine and may at times produce some mild subjective improvement but no matter how much is given they do not even approach a cure. *Arsenic therapy* first suggested in this country by Bumpus¹ appears specific. In our experience the employment of neoarsphenamine has been followed by distinct improvement frequently after the first injection. General recovery is absolute after three or four injections despite vain efforts for months or years when other methods have been employed. Our experience coincides with others in that only a few injections and only small doses of neoarsphenamine are needed. Symptomatic improvement is obtained immediately and only four or at best five injections are necessary to effect a clinical cure. We would suggest that the initial dose be 0.15 gm, that the second dose be 0.3 gm, and the next three doses be 0.45 gm perhaps on every third or fourth day. It does not seem necessary to increase the dosage over 0.45 gm.

Of course until such time as the diagnosis is made and specific therapy instituted the patient's discomfort should be controlled by adequate sedation. Fluids should be forced to over

come the tendency to dehydration caused by the patient's pain, restlessness, sleeplessness and general increase in activity.

COMMENT

The offending organism in primary sterile pyuria is one that either does not lend itself to ordinary staining methods or culture by ordinary media or perhaps is a virus like organism. It is appreciated that patients suffering with this type of infection are uncommon and that resorting to this form of therapy simply because sulfonamide or mandelic acid therapy has been ineffective would be distinctly harmful. However, this type of infection must be kept in mind.

CONCLUSIONS

- 1 Primary sterile pyuria must be regarded as a distinct clinical entity.
- 2 Its importance lies in its simulation of urinary tract tuberculosis.
- 3 Arsenical therapy is specific.

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TOTAL GASTRECTOMY FOR MALIGNANCY

SAMUEL F. MARSHALL and WILLIAM ZINTL

RADICAL operations for malignancy of the stomach have proved justifiable in view of encouraging results. Subtotal gastrectomy has long been accepted by the medical profession for the treatment of carcinoma of the stomach but there has always been some hesitancy in accepting complete removal of the stomach for the more extensive lesions. Too often a spirit of pessimism has prevailed concerning the treatment of malignancy of the stomach but in spite of this a gradual reduction in operative mortality and an improvement in the surgical results have demonstrated beyond question the value of surgery.

More recently the operability of malignancy of the stomach has been increased by resection of more extensive lesions that were heretofore considered inoperable. Widespread involvement of the stomach unless there is distant metastasis or direct extension to adjacent irresectable structures lends itself to total resection. This tendency to extend operation to the more advanced cases of malignancy which has resulted in a higher mortality as compared to subtotal gastrectomy is justifiable in view of results.

Since 1929 55 total gastrectomies have been performed in the Lahey Clinic 46 of which were done during the last five years by six members of the staff. Eighteen deaths resulted a mortality percentage of 32.7 (Table I) whereas the mortality

TABLE I

Cause of Death Due to Operability (18 Patient)

Intoxication	9
Shock	2
Coronary occlusion	2
Myocardial infarction	2
Pulmonary embolism	2
Bronchopneumonia	1
Total	<hr/> 18

following subtotal gastrectomy is much lower. In a previous group of cases our mortality for subtotal gastrectomy for car-

cinoma was 77 per cent.¹ The postoperative results in the group surviving operation more than justify the increased risk involved (Tables 2 and 3)

TABLE 2

LENGTH OF LIFE FOLLOWING OPERATION (21 PATIENTS)

Less than 6 months	3
6 months to 1 year	4
1 year to 18 months	7
18 months to 2 years	5
2 to 3 years	1
3 to 4 years	1
Total	21

TABLE 3

PATIENTS STILL LIVING FOLLOWING TOTAL GASTRECTOMY (16 PATIENTS)

6 months or less	5
6 to 9 months	2
9 months to 1 year	1
1 year to 18 months	2
18 months to 2 years	1
2 to 2½ years	2
4 to 5 years	2
5 years plus	1
Total	16

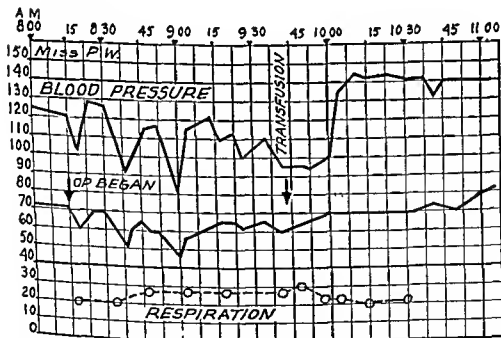


Fig 235—Total gastrectomy for carcinoma simplex involving major portion of stomach. A woman 54 years of age symptoms of one year's duration. Blood pressure and respiration curves during operation note effect of transfusion. Systolic and diastolic pressures normal at completion of operation. Pulse rate varied from 90 to 110 throughout. Pontocaine fractional spinal anesthesia.

Radical surgery is a reasonable procedure when one considers that all of these patients with advanced disease are doomed to early death. Any increase in the length of life is worth while and in most cases the death of a patient with an unoperated carcinoma of the stomach is most distressful. Abdominal discomfort, nausea, vomiting and anorexia may be marked. Certainly the suffering is not increased after operation and in the majority of patients recurrent carcinoma causes remarkably little

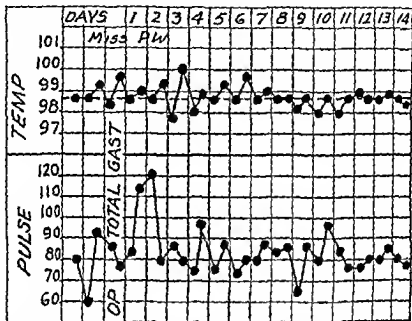


Fig. 236—Postoperative course of patient in Figure 235. Note temperature never elevated above 100° F. following operation and normal after seventh day. Patient made uneventful recovery, is well and has good appetite. No difficulty in swallowing food.

distress. The immediate postoperative discomfort following total gastrectomy is minimal and usually is no more than that following exploratory laparotomy. Figures 235 and 236 illustrate the usual course of a patient during and following the operation of total gastrectomy. Following total gastrectomy those patients who survive operation are quite comfortable, develop an appetite for food, experience hunger and gain weight. Many return to gainful occupations and lead normal lives until recurrence causes death. There is, of course, always the remote pos-

sibility of a cure, and a few of our patients have already lived over a considerable period without evidence of recurrence.

The much quoted paper of Finney and Rienhoff³ published in 1927 probably did much to stimulate interest in this problem. These authors collected 67 cases from the literature and reported an average mortality of 50 per cent peritonitis and shock being responsible for most of the deaths. Since that time total gastrectomy has been performed successfully by many surgeons. Allen¹ reports 15 cases from the Massachusetts General Hospital with an operative mortality of 46 per cent. Many improvements in preoperative preparation, in anesthesia and in operative technique as well as in postoperative care have contributed much to the safety of such a radical procedure.

Selection of Patients for Operation

The reduction in mortality rate resulting from these technical advances, however, has been more or less offset by the tendency of surgeons with more experience in this field to accept a group of patients with a much higher operative risk, with a consequent increase in operative mortality. This is true in our experience at the Lahey Clinic as evidenced by the greater number of total gastrectomies performed in the last five years. As the surgeon's experience in this type of surgery increases, the tendency is to accept greater operative hazards. However, since this may be extended beyond a desirable point, experience should teach the surgeon to distinguish the unresectable cases and restrain him from undertaking needless operations.

The number of carcinomas of the stomach which requires total gastrectomy naturally is limited. The linitis plastica type of carcinoma is the most favorable lesion for such radical surgery. This is a diffuse fibrocarcinoma which grows along the muscle planes, has late metastatic spread and does not extend to adjacent organs. A carcinoma of the cardia of the stomach also can be removed by complete gastric resection, however, recently some surgeons have advocated transthoracic removal. If there is no esophageal involvement, this approach is unnecessary, carries an increased operative risk, and most important does not permit adequate removal of gland groups. One patient in this group who had a total gastrectomy for a large adenocarcinoma of the cardia with gland involvement is without re-

currence after four years Simple resection of the stomach for carcinoma without careful removal of all gland groups is not a thorough operation and is to be condemned Gland groups draining various areas of the stomach can be removed only by wide exposure and through an adequate abdominal incision during adequate resection for carcinoma of the stomach Their careful removal is just as important as the removal of glands in radical mastectomy for breast malignancy Advanced malignancies of the stomach are amenable to total gastrectomy only if minimal local gland involvement is present There must be no extension of the tumor to adjacent structures or widespread metastases no matter how small Such radical surgery is useless unless there is reasonable hope of removing completely all gross tumor A case of questionable operability should certainly not be considered and will only serve to discredit the operation

Preoperative Preparation

The preoperative preparation of a patient with carcinoma of the stomach is most important With few exceptions the need for a total gastrectomy cannot be anticipated before the abdomen is opened Many of these patients are in a poor state of nutrition Fluid and mineral balance needs to be restored Blood transfusion is often necessary not only to restore red blood cells and hemoglobin but also blood protein to normal levels Vitamin C is given daily in sufficient dosage and glucose is administered for liver storage If obstruction is present decompression of the stomach by Levin tube is desirable and just before operation we routinely lavage the malignant stomach with a solution of 7.5 cc of concentrated hydrochloric acid in 1 liter of water⁸

Anesthesia

Advances in anesthesia probably have contributed the greatest single factor of safety Adequate anesthesia which can be prolonged or renewed without interruption which gives complete relaxation and allows full exposure at all times reduces trauma and facilitates each technical step In five years we have had no death due primarily to pneumonia following total gastrectomy We employ routinely *fractional spinal anesthesia* using the method developed by Lemmon⁶ and find this form of anesthesia completely satisfactory

Exposure

The abdomen is opened through a left rectus incision long enough to permit ready exposure of the stomach and of the upper abdominal cavity. It can be extended as far below the

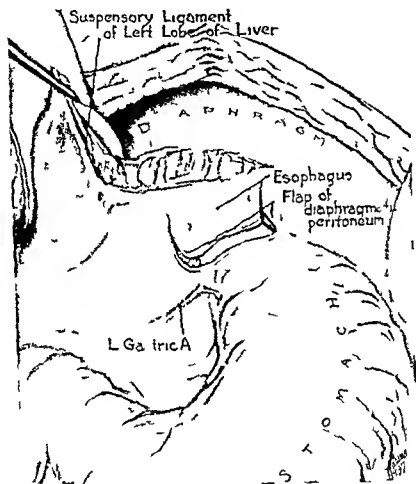


Fig. 237—Total gastrectomy. The stomach is approached through a left rectus incision. The ligament attaching the left lobe of the liver to the diaphragm is divided and the left lobe is retracted medially. This exposes the diaphragm and the esophagus. The peritoneal flap over the esophagus is now outlined. This peritoneal flap is sutured to the jejunum at the completion of the esophagojejunal anastomosis.

umbilicus as necessary and commonly extends to the costal margin between the left costal cartilages and xiphoid process of the sternum. In our experience incisions involving the division of the costal margin have proved unnecessary. It should be emphasized that before complete removal of the stomach is con-

sidered the surgeon should determine the extent of the tumor. The lesser omental cavity must be opened through the gastrohepatic omentum and any adherence or extension to the pancreas or to retrogastric tissues should be determined. Gland involvement around the celiac axis should be estimated and finally a search should be made for direct extension of the gastric lesion to the diaphragm. It is assumed that extension to the esophagus has not been demonstrated by roentgenologic and esophagoscopic examinations prior to laparotomy. The cardia and esophagus are readily exposed by detaching the left lobe of the liver from the diaphragm as suggested by Turner¹⁰. The liver can then be retracted medially and the esophagus and diaphragm are easily exposed (Fig. 237).

Technic of Resection

A previous publication from this Clinic⁴ gives in detail the method of total gastrectomy developed here; consequently the details of technic will not be repeated (Figs. 237 and 238). With minor modifications this method is routinely employed by our staff. We believe the entire omentum should be removed as it simplifies the mobilization of the stomach and removes the gland groups along the greater curvature which are so commonly involved. The detachment of the omentum from the colon as advocated by Ogilvie⁶ is extremely simple and actually requires less ligation of vessels than division and ligation of the gastrocolic omentum.

Splenectomy with Gastrectomy

Another publication from this Clinic⁵ emphasizes the value of occasional splenectomy in total gastrectomy and in this series this procedure was performed in 19 cases. This procedure prevents troublesome bleeding from the vasa brevia vessels running from the greater curvature of the stomach to the spleen, provides better exposure of the diaphragm and lower end of the esophagus and apparently does not add to the operative risk (Fig. 239). One of the most commonly involved groups of glands is the splenic group situated along the splenic vessels from the stomach to the hilus of the spleen. They drain the fundus of the stomach and become involved when a high lesion of the fundus or cardia is present. Of equal importance is the removal

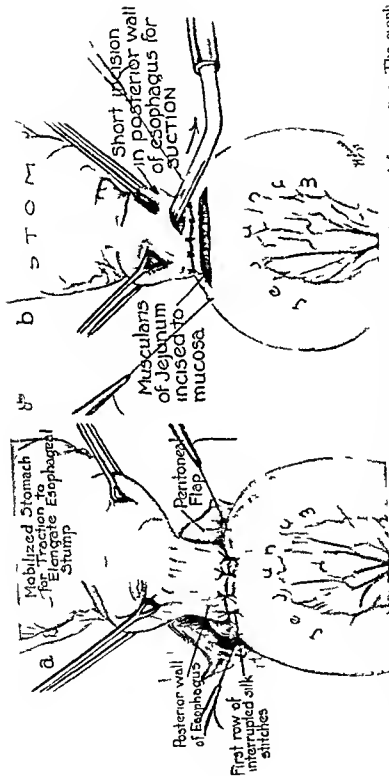


Fig 338—Total gastrectomy *a* The stomach has been completely mobilized and retained for traction. The esophagus has been freed from the diaphragm and exposed for some distance so that anastomosis to the jejunum is made possible. A posterior row of interrupted black silk sutures unites the esophagus and the jejunum. *b* The jejunum is incised and the esophagus opened sufficiently to permit suction of the contents. After the jejunal mucosal incision is made a posterior row of interlocking catgut forms the second suture layer from right to left detaching the anterior wall of the esophagus as the suturing proceeds.

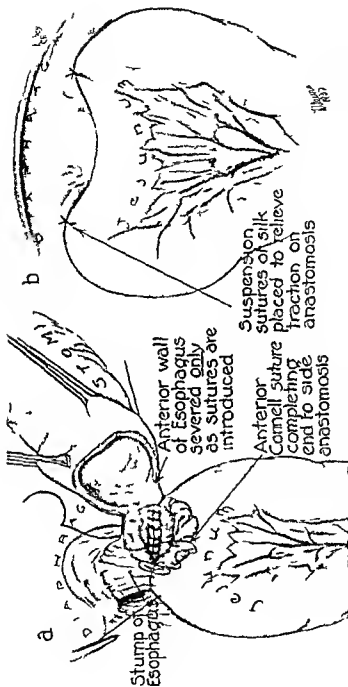


Fig 239 Total gastrectomy with esophageal anastomosis. (a) Stump of esophagus with anterior wall severed only as sutures are introduced. (b) Completed anastomosis with suspension sutures of silk placed to relieve traction on anastomosis.

of the coronary nodes which lie along the coronary artery and drain the cardia and lesser curvature. If this artery is divided

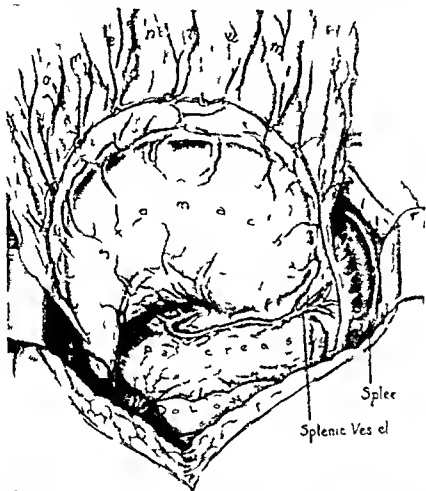


Fig 740—Total gastrectomy. The great omentum has been detached from the transverse colon and turned upward with the stomach. This exposes the posterior gastric or coronary artery, the splenic vessels, pancreas and spleen. The point of ligation of the splenic vessels is indicated if splenectomy is combined with total gastrectomy.

close to its origin off the celiac axis, these glands along with the vessels can be stripped up readily.

Pathology of the Tumors

The pathology of the tumors in this group is interesting (Table 4). Lymph node invasion was present in 44 of the 51 cases of gastric carcinoma. Ewing states that he has found lymph node invasion in practically every case of gastric resection for ulcerating carcinoma.

TABLE 4

PATHOLOGIC DIAGNOSIS (55 TOTAL GASTRECTOMIES)

Carcinoma simple with gland involvement	27
Carcinoma simple without gland involvement	2
Adenocarcinoma with gland involvement	17
Adenocarcinoma without gland involvement	3
Colloid carcinoma	1
Epidermoid carcinoma	1
Lymphoblastoma	2
Leiomyosarcoma	2
Total	55

Postoperative Results

The youngest patient was 27 years of age and the oldest was 72. Both patients of these extremes in age were resected successfully. Forty-five patients were in the fifth, sixth and seventh decades which corresponds to age groups in which most malignancy of the stomach occurs.

As mentioned before there were 18 postoperative deaths in this series of 55 cases of total gastrectomy, a mortality percentage of 32.7. 16 of the patients in the group are still alive and well. Since discharge from the hospital 21 patients have died. The length of time this latter group survived operation is shown in Table 2.

One patient in this group lived three and a half years and was able to work satisfactorily. Most of the patients lived a year or longer with reasonable digestive comfort and with little of the distress that accompanies an extensive ulcerating lesion of the stomach.

Many patients have comfortable prolongation of life and this in itself makes the operation worth while. One patient, a woman, is alive and well after four years, the tumor removed being a lymphoblastoma involving the whole stomach. She maintains her weight, is able to earn her living and has no evidence of recurrence. Another patient who was operated upon at the age of 77 years for an extensive leiomyosarcoma has been well for over five years and in view of the relative low grade malignancy may possibly be cured. Another patient who had an adenocarcinoma with gland metastasis has lived four and a quarter years with no evidence of recurrence. Two patients have lived two years without recurrent tumor and 3 have been well for more than a year.

As would be expected the principal cause of death imme-

diately following operation was peritonitis (Table 1) Perhaps in the future some of these deaths can be avoided by intra abdominal sulfanilamide Only 2 patients died of shock this is gratifying in view of the magnitude of the operation and the extreme age of many of these patients Well controlled anesthesia the use of blood transfusion and the absence of operative trauma will do much to prevent shock All of these patients received blood transfusion during or after operation

In this paper no attempt will be made to discuss diet It is gratifying to see these patients acquire an appetite and soon return to an adequate diet They have little digestive discomfort are able to maintain nutrition and in most cases carry on their usual activities

Occasionally following discharge from the hospital a patient develops some constriction at the esophagojejunal anastomosis This is due to scar tissue contraction at the stoma Difficulty in swallowing solid foods which is the chief complaint can be demonstrated readily by fluoroscopy with a small amount of barium Difficulty of this nature does not necessarily mean recurrent carcinoma and it can be corrected by simple dilatation with an olive tipped bougie

SUMMARY

Experience and surgical judgment are necessary in the selection of patients with advanced carcinoma of the stomach who would be benefited by total gastrectomy Removal of the omentum is suggested along with splenectomy as indicated in selected cases Total gastrectomy is consistent with life Digestion and nutrition can be maintained and reasonable health may be expected

The operative mortality in 55 cases was 32.7 per cent A few patients are reported to be well two three four and five years following total gastrectomy

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TENOSUSPENSION OPERATION FOR RECURRENT OR HABITUAL DISLOCATION OF THE SHOULDER

MELVIN S. HENDERSON

A shoulder joint may be said to be subject to habitual or recurrent dislocation when dislocation occurs irregularly as a result of some trivial voluntary manipulation or effort on the part of the patient. A number of patients encountered at the Clinic have experienced hundreds of dislocations and the chief purpose of this paper is to record the results of fifty five tenosuspension operations performed at the Clinic on fifty one patients through a period of eighteen years.

ANATOMIC CONSIDERATIONS

The shoulder joint is a true ball and socket joint with the ball much larger than the socket only a small portion of the surface of the head rests in the socket at any one time. The socket is formed by the glenoid fossa of the scapula and is slightly deepened by the cartilaginous fibrous rim called the glenoid labrum. This rim recently has received renewed attention and detachment of a portion of the rim from the glenoid process has been considered by some authorities as the basic cause of recurrent dislocation. The capsule of the joint is lax and permits of an extraordinary range of motion. This range is so great the wonder is that dislocations are not more common. The reason for the comparative rarity of recurrent dislocations of the shoulder is that the play and interchange of muscular forces are so well synchronized that protection is afforded by the muscle balance and tension. Some anatomists believe the negative pressure in the joint helps also. In my opinion when recurrent dislocations occur something has gone amiss with

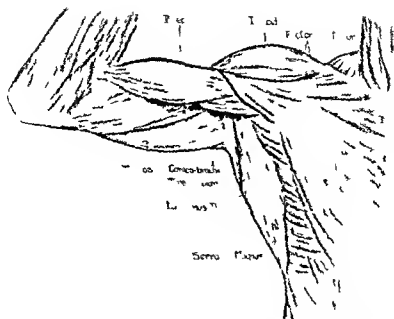


FIG. 24. Anterior view showing muscular arrangement about the shoulder.

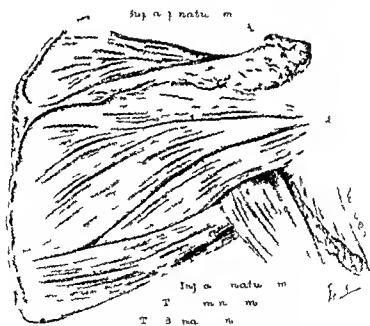


FIG. 24. —Posterior view of shoulder showing insertion of supraspinatus, infraspinatus and teres minor muscles.

this stabilizing muscular balance. However to say which muscles are at fault or why such an incoordination should develop is another story.

The shoulder joint is covered (Figs 241, 242 and 243) over all by the fan shaped deltoid muscle. Its action is to aid in holding the head of the humerus in the glenoid fossa. The tendons of the supraspinatus, the infraspinatus and the teres



Fig 243—Anterior view of scapula showing insertion of subscapularis and teres major muscles

minor muscles are inserted into the greater tuberosity of the humerus. They tend to strengthen the capsule superiorly and posteriorly and tend to hold the head in the socket. One would expect the supraspinatus to hold up the head more than the others. The lesser tuberosity of the humerus is situated anteriorly and on this is inserted the strong rather flattened thin tendon of the subscapularis muscle. No other muscles are in

serted into the capsule part of the triceps muscle has its origin at the lower margin of the glenoid fossa but in no way does this strengthen the capsule. The weak portion of the capsule lies between the insertion of the subscapularis and the origin of the triceps on the lower glenoid margin. The superior and inferior glenohumeral ligaments are attached high on the anterior margin of the glenoid cavity and close to the origin of the long head of the biceps muscle thus they give no real support to the weak anterior inferior portion of the capsule. Man differs from the quadruped in that there are no strong anterior ligaments to prevent displacement of the head of the humerus. The long head of the biceps is credited with contributing support to the shoulder joint. Running as it does from the top of the glenoid rim down through a groove in the humerus to be inserted into the radius this tendinous structure does give some support.

SYMPTOMS SIGNS CAUSES AND PATHOLOGIC FEATURES

A patient who is subject to recurrent dislocation of the shoulder is constantly apprehensive the degree of his apprehension depending on the number of dislocations he has sustained. When the shoulder becomes dislocated the patient is immediately incapacitated because of the severe pain. The objective signs are a depression beneath the acromion process flattening of the shoulder fullness just below the coracoid process slight abduction of the elbow from the side of the body and increase in length of the arm.

The history given by many patients is that dislocation occurs most commonly when they abduct the arm and reach forward as to a shelf on which rests an object which they wish to take in hand. One patient reported that his first dislocation occurred as he jumped over a fence and raised his arms as one does in such an act in an effort to maintain balance. In an effort to determine the cause of the initial dislocation particularly in sports I found by reviewing our records that football basketball handball swimming and diving hockey boxing and wrestling were mentioned but bowling was not. This is interesting because Davis exercises which will be described under treatment involve the muscles used in bowling. Strange to say no patient volunteered the information that a dislocation occurred while playing golf.

Bankart¹ has insisted that the morbid anatomy in this condition is definite. He expressed the belief that the lesion is a detachment of the capsule with or without the glenoid labrum from the anterior lip of the glenoid cavity. He maintained that the dislocation is directly anterior and that it is produced by direct violence to the shoulder or arm from behind. This can occur but it is by no means as common as the usual mechanism which comes into play when the arm is held somewhat abducted and forward, with the hand in pronation thus forcing the head of the humerus against the weak anterior inferior portion of the capsule. Bankart did not directly state that recurrent dislocations follow traumatic dislocations of the anterior type which he described and that they do not follow the more common type of primary dislocation in which the head descends first and then slips up beneath the coracoid process. Still the implication seemed to be that the foregoing was his belief.

Another author to whom I wish to refer is Eyre Brook of the Bristol Royal Hospital Orthopaedic Service. He operated on a woman thirty six years of age who was subject to epileptic seizures. Unfortunately at the close of a Nicola type of operation for recurrent dislocation of the right shoulder done under anesthesia the patient's heart stopped she could not be resuscitated and death ensued. Thus an opportunity for a complete examination of the shoulder joint presented itself. Eyre Brook demonstrated the detachment of the capsule from the rim of the glenoid cavity and its complete failure to become re attached. He continued, saying that although the lesion described by Bankart was not universally accepted still no other lesion had been reported so consistently by those who exposed the anterior margin of the glenoid cavity. Eyre Brook also commented on certain bony deformities mentioned in the literature. His observations failed to reveal any etiologic significance in what has been referred to as the 'hatchet' deformity. This is a varus deformity, with some elongation of the neck of the humerus and is supposed by a cam like action of the head of the humerus against the anterior capsule to favor dislocations. Another bony deformity noted by Eyre Brook in the case he reported was notching of the posterior surface of the head a condition not infrequently encountered. The notching cannot be demonstrated at operation carried out through anterior incisions but it can be demonstrated by roentgenograms taken

from above with the arm in midrotation in the coronal plane. Some contend that this may be a congenital defect but it probably is the result of the position that the head assumes resting against the anterior rim of the glenoid fossa when the dislocations occur. It is most likely a result of rather than a cause of the dislocations. As the notch becomes deeper and the diameter of the head less the dislocations are made easier because the capsule is too large. Lyre Brook's contribution is in support of Bankart's lesion as the cause of recurrent dislocations.

At the Clinic we have had roentgenograms of the shoulder taken in all our cases but little of consequence has been noted. Recently we have had two views made, one from above with the arm in the position of midrotation and the other the orthodox anteroposterior view. Most of the roentgenograms have been discarded as negative but a review of our later cases shows that there is occasionally a defect or flattening in the posterior portion of the head of the humerus. We have not noticed the so called hatchet deformity mentioned by Tavernier.

TREATMENT

Treatment falls into two groups, nonsurgical and surgical treatment.

Nonsurgical Treatment

This consists either in the wearing of some type of apparatus to prevent abduction of the arm or the carrying out of a regimen of exercises. There is some hope that by the patient's taking care to avoid the movements which produce the dislocations over a long enough period, cure will be effected. However, such avoidance is irksome and few will endure the inconveniences. Systematic exercises may offer more than has been appreciated in the past. Davis has offered a definite program of exercises preceded by strapping with adhesive tape to restrict motion. Thus far his cases are too few to prove the efficacy of the measure and it only can be hoped that he will have more to report on this method of treatment in the future. The goal at which he aims is overdevelopment of the internal rotators by exercises consisting of a thrust of the arm across the abdomen and downward toward the opposite thigh with the forearm pronated. The muscles so exercised are the anterior portion of the deltoid, the pectoralis major, the sub

scapularis the teres major and the latissimus dorsi. The exercise in bowling is somewhat similar to this and the similarity was brought to my attention by a letter from one of our epileptic patients who failed to obtain relief from a tenosuspension operation. Following the operation he reported numerous dislocations but he began bowling, cautiously at first, and he stated that from that time (three years previously) he had had no dislocations and in his opinion the shoulder was normal.

Surgical Treatment

The operative procedures suggested are many. Earlier in this paper considerable attention was given to *Bankart's operation*. A brief description of that procedure is as follows: (1) A long anterior incision is made and the dissection is carried down between the deltoid and the pectoralis major muscles; the pectoralis major is partially separated from the humerus to give exposure. (2) The tip of the coracoid process, with the attached short head of the biceps and the origin of the coracobrachialis is turned downward and pulled internally. (3) The tendon of the subscapularis, a broad flattened structure is divided near its insertion in the lesser trochanter and likewise is reflected inward, thus exposing the anterior aspect of the shoulder. (4) The exposed capsule is opened and according to Bankart the glenoid labrum will be found detached. (5) The labrum is then sutured to the bony margin. This is not an easy procedure and should not be undertaken until one is thoroughly familiar with the anatomy. Bankart's operation is in reality a thorough and complete capsulorrhaphy. Evidently capsulorrhaphy as performed in the past was not sufficiently extensive. Thomas^{7, 8, 9} in his work on capsulorrhaphy hinted at but never quite described the lesion indicated by Bankart.

Bost and Inman of the University of California after perusal of the arguments contained in Bankart's last article decided to give his operation a trial. Their paper is an excellent one dealing particularly with the anatomy and containing a discussion of the pathologic characteristics. Their ten patients were observed from six weeks to thirty nine months following operation. Eliminating the patient whose condition was observed six weeks following operation as too recently operated on to support judgment in regard to end results, nine patients remain observed from seven to thirty nine months after opera-

tion Only one patient an epileptic sustained recurrence of the dislocations

If Bankart is correct and his observations were carefully made and have been substantiated by others then it would be logical to assume that his operative procedure should be universally adopted However as has been said it is a more or less formidable procedure and it may well be worth while to consider the good results reported following other simpler operations which do not pay heed to the pathologic conditions described by Bankart

Nicola^{9 41} has taken advantage of the course of the long head of the biceps through the groove in the humerus and has used the long head as a suspending ligament for the head of the humerus He and others have recorded excellent results following his operation Roberts has modified Nicola's technic in that he does not pull the upper part of the divided tendon up and then pull it down through the drilled humeral head into the groove he scarifies the tendon and places it back in the thoroughly freshened groove Burnet has reported favorably on this operation Another ingenious operation is that of Carrell He severs the long head of the biceps transfers the distal portion to the short head and lengthens the proximal portion of the long head of the biceps tendon by attaching to it a strip of fascia lata This strip is passed posteriorly through the axillary space and is fastened to the acromion process acting as a sling for the head of the humerus

In an excellent article written in 1939 Gray concisely reviewed the whole subject and in particular the treatment He referred to Young's operation of dividing the tendinous portions of the insertion of the pectoralis major and the latissimus dorsi muscles Many years ago at the Clinic we tried this method in two cases and neither patient was cured The bony block operations are ingenious but I have had no experience with them The object is to increase the anterior lip of the glenoid fossa by a sort of bony block as in Eden's Speeds and Hildebrand's methods or to increase the size and length of the coracoid process for an anterior block as in the operation of Bazy and Calvet and in that of Oudard Gray continued mentioning the operations of Nicola Roberts Groves (an axillary sling of fascia lata) Gallie and LeMesurier¹ (fascial weaving in an attempt to strengthen the inferior glenohumeral

ligament) and the tenosuspension operation that bears my name^{1 16 17} Gray favored Banhart's procedure. However in his discussion of results the following interesting statement was made. It appears from the literature that nearly all the operations described give very good results. His unfavorable comment on the Clairmont muscle sling operation coincides with our experience at the Clinic. Although Gray favored both Gallie's¹¹ and Banhart's operations he admitted that they necessitate formidable dissection and are not simple to perform. He

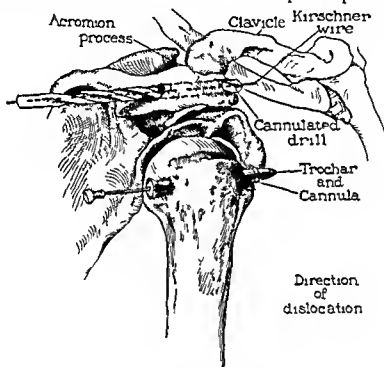


Fig. 244—Cannulated drill inserted over the Kirschner guide wire. Trocar and cannula aid passage of the tendon through the bone.

offered no proof that the results are better than those obtained by the tenosuspension procedure. Consequently we at the Clinic have decided to continue to employ our tenosuspension operation. The objection to the necessity of removing a piece of peroneal tendon from the leg in the tenosuspension procedure is theoretical. It requires but a short time and can be done through two small incisions.

Tenosuspension Operation—The tenosuspension operation is just what its name signifies, namely, a procedure whereby the head of the humerus is suspended by means of a piece of tendon.

The operation is entirely extra articular and the object is to provide the shoulder with a ligament which will prevent downward and forward displacement of the head of the humerus. The tendon is placed in the form of a loop with an anterior and posterior sling.

The technic of the tenosuspension operation is simple. The patient is placed on the side between sand bags with the affected shoulder uppermost. General anesthesia is used. The

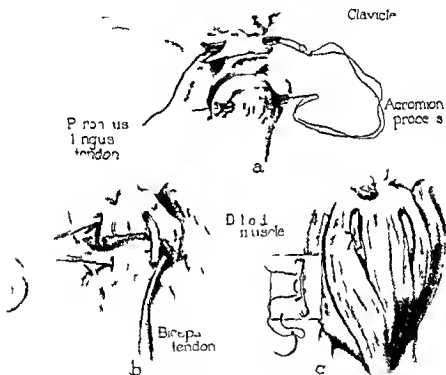


Fig. 245—Insertion of tendon a b and c

skin is prepared in the ordinary manner and the forearm and hand are wrapped in a sterile sheet so that the arm can be moved at will. The leg on the same side is prepared from the knee downward. One of two methods of incision in the shoulder may be used. (1) The saber type of incision may be made whereby the skin can be reflected away from the area to be exposed. (2) Three or four small incisions for example two in front and one in back may be used in operating on women. It

should be remembered that the smaller the scars the better satisfied the patients will be. Holes are then drilled through the acromion process and through the upper end of the humerus lateral to the joint line about the region of the greater tuberosity (Fig 244). A Kirschner guide wire is used and over this a cannulate drill is inserted. To facilitate drawing the tendon through these rough bony channels I have used cannulas such as are represented in Figure 245 or a Macey tendon puller (Fig 246 *a* and *b*). Through two incisions such as are represented in Figure 247 the tendon for the new ligament is ob-



a



b

Fig. 46—Tendon and fascia passer *a* in closed position a forward movement of the closing handle brings the two blades of the forceps together *b* with blades of the forceps open to receive material to be passed

tained from the peroneus longus of the leg on the same side as the affected shoulder. The peroneus longus is exposed at the juncture of the lower and middle thirds of the leg and is cut with a step (Fig 247). It is then loosened in its sheath by blunt dissection with a curved hemostat and is pulled out through a small lower wound on the outer edge of the foot where the tendon turns to cross the sole of the foot. Half of the tendon is then removed for making the new ligament (Fig 247). The remaining portion of the tendon is then pulled back up through its sheath behind the external malleolus and the end is fastened to the upper end of the divided tendon (Fig 247). The wounds

are closed in the usual manner and the arm is held to the side for approximately ten days. Following that some movement is permitted. Abduction to a right angle is not permitted for at least eight weeks. If the patient is subject to epileptic seizures protection should be provided even more carefully and hypnotic drugs should be used freely to ward off seizures.

The success of the operation depends on proper insertion of the ligament and dissection through the deltoid muscle.

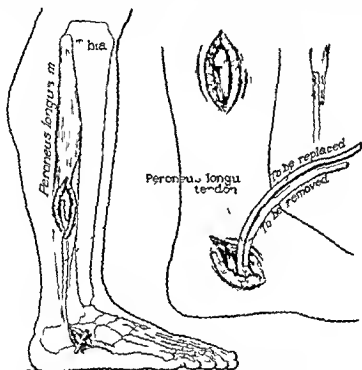


Fig. 247—Method of obtaining piece of peroneus longus tendon

down into the capsule of the joint must be done carefully enough so that the peroneus longus transplant is deeply placed and lies directly along the capsule thus providing a snug fit. If the new ligament is so lax as to be loose recurrences will develop. If the dislocations are of the directly anterior type and very easily produced the tendon must be placed even more snugly so that the new ligament will prevent any excursion of the head forward. The operation is not suitable for the posteriorly dislocating shoulder type which is really rare. In such instances posterior capsulorrhaphy is the operation of choice.

and is satisfactory. It is possible that a certain percentage of the dislocations which occur among patients with epilepsy are directly anterior. In those cases, the tendon especially the posterior sling must be snugly placed, as has been mentioned.

More than 90 per cent of the entire group of patients were cured by the tenosuspension operation, whereas in the group consisting of the nine patients who had epilepsy three operations resulted in failure. If the epileptic patients were excluded the percentage of cures in the remaining number would be approximately 95. As was noted in the report by Bost and Inman their one failure was in the case of an epileptic patient on whom they had performed the Bankart operation.

If the operation is not to be a success, in our experience at the Clinic the dislocation usually recurs in less than a year from the time of the operation. In our series there are fifty one patients on whom fifty five tenosuspension operations have been performed for recurrent dislocation of the shoulder. Our first tenosuspension operation was performed in 1924. As the result of fifty five operations on fifty one patients, fifty or 90 per cent of the operations were successful. I believe most of the failures were due to errors in technic. For example the tendon may have been placed too superficially and loosely or the ends may not have been sutured together carefully. The bony canal must provide a fairly snug fit for the piece of tendon and must not permit of easy gliding back and forth. The tendon must be deeply placed and undue strain such as might be produced by epileptic seizures on the newly placed tendon must be avoided until it grows fast to the bony canal. Any operation performed so rarely is certain to be attended by a definite percentage of costly technical errors.

In carefully reviewing the records of the five patients concerning whom recurrences were reported in our series I find that three were subject to epilepsy. It is probable that in two of the three cases epileptic seizures closely following the operation had at least something to do with the recurrence of the dislocations. In two of the remaining cases a note was made at the time of operation stating that the loop of tendon in front was not placed directly on the capsule but traversed the layers of a heavy deltoid muscle. In the last of the five cases it was noted that the piece of tendon was a bit short and that the ends were rather unsatisfactorily brought together.

TABULATION

RECURRENT DISLOCATION OF SHOULDER NO DISLOCATION SUBSEQUENT TO TENOSUSPENSION OPERATION IN 46 OF 51 CASES

Case	Age Years and Sex	Occupation	Initial Injury	Dislocation Before Operation	Shoulders Affected	Dates of 54 Operations	Time from Operation to Last Check up	Result
1	31M	None	Epiphyseal fracture	30 (Previous operation)	L ft	June 12 24	18 years	Success
2	33F	Housewife (epiphyseal)	Unknown	32	Left	Apr 30 25	14 years	Success
3	32F	Housewife	None	12	Right	Sept 11 25	15 years	Success
4	26M	Tool dresser	Football	15	L ft	Aug 19 26	10 years	Success
5	23M	Student	Unknown	Many (?)	Right	Apr 5 27	7 years	Success
6	22M	Prizefighter	Boxing	7	Both	Apr 9 28	7 years	Success
7	39F	Domestic	Tennis	Many (?)	Right	Aug 14 28	11 years	Success
8	23M	Miner	Boxing	15	Left	Dec 6 28	6 years	Success
9	37F	Secretary	Fall	10	Right	Aug 15 29	12 years	Success
10	26M	Cabinetmaker		9	Right	Oct 4 29	5 years	Success
11	36M	Ordnance drill	Fall	20	L ft	Mar 6 30	5 years	Success
12	26F	Industrial (pulp)	Fall	22	L ft	Mar 12 30	5 years	Failure

13	23M	Student	Dislocation	12	Right	June 12 30	5 years	Failure
14	24M	Laborer	Fall	2	Right	June 28 30	5 years	Success
15	29M	Student	Epileptic seizure	25	Right	Oct 17 31	3 years	Failure
16	21M	Student	Football	113 (Previous operation)	Right	Nov 17 31	3 years	Success
17	39M	Dentist	Diving	20	Left	Dec 7 31	10 years	Failure
18	27M	Timekeeper	Boxing	30	Left	June 8 33	8 years	Success
19	26F	Domestic	Fall	Many (?)	Right	Nov 28 33	9 years	Success
20	50M	Miner	Pushing tram car	Left 2 Right 3	Both	Feb 9 34 Jan 13 34	8 years	Success
21	18M	Student	Fall	40	Left	Mar 21 34	6 years	Success
22	24M	None	Tumbling	10	Right	June 20 34	8 years	Success
23	17M	Student	Football	5	Left	Aug 3 34	3 years	Success
24	20M	Rancher	Boxing	30	Right	Dec 5 34	5 years	Success
25	25M	Drugstore clerk	Epileptic seizure	5 a day	Left	Jan 18 35	7 years	Success
26	23M	Student	Football	Many	Both	{R} Jan 28 35 {L} Feb 11 35	3 years 3 years	Success
27	20F	Student	Fall	20	Left	May 8 35	7 years	Success
28	16F	Student	Fall from bicycle	10	Right	June 24 35	7 years	Success

TABLE IV--Continued

Care	Age Years and Sex	Occupation	Initial Injury	Duration of Operation	Shoulder Affected	Date of Onset	Time from Onset to Last Check up	Result
9	23M	Laborer	Fall from horse	4	Right	Nov 12 05	years	Success
10	22M		Fall	5	Right	Dec 5 35	1 year	Success
31	21M	Chemist	Hidball	9	Right	July 4 36	2 years	Success
32	24M	Attorney	Fall	11	Right	Oct 8 36	6 years	Success
33	28M	Nurse	Non	?	Right	Jan 26 37	2 years	Success
34	21M	Highway	Hocky	20	Right	May 0 37	7 years	Success
35	22M	Truck driver	Boxing	3	Left	Sept 4 37	5 years	Success
36	26M	Physician	Unknown	11	Right	Oct 1 37	5 years	Success
37	23M	Student	Hocky	10	Left	July 6 38	4 years	Failure
38	19M	Student	Baseball	11	Right	Oct 5 38	4 years	Success
39	19M	Teacher	Epiphyseal	100	Right	Jan 7 39	3 years	Failure
40	4M	Student	Epiphyseal	Many	Both	(1) July 3 39 (2) Oct 28 40	3 years 2 years	Success
41	20F	Student	Football	12 (Perv)	Right	Jan 27 41	2 years	Success

42	20I	Student	Right	100	Right	June 27 40	2 years	Success
43	30M	Clerk in store	Left	60	Left	June 3 41	1 year	Success
44	34M	Farmer	Left	40	Left	June 16 41	1 year	Success
45	32M	Teacher	Right	300	Right	June 5 41	1 year	Success
46	21F	Domestic	Left	4	Left	Dec 1 41	1 year	Success
47	22M	Student	Left	Many	Left	Feb 5 42	6 months	Success
48	22M	Farm laborer	Left	35	Left	Feb 14 42	1 year	Success
49	21F	None	Left	100	Left	May 13 42	6 months	Success
50	18M	Student	Left	12	Left	June 11 42	6 months	Success
51	19M	Student	Right	20	Right	July 29 42	6 months	Success

Success No dislocations following tenosuspension operation
 Failure One or more dislocations following tenosuspension operation

In this series there were no cases of infection of any consequence. The average length of time in bed was about ten days. Care must be taken to control any bleeding along the outer margin of the foot where the peroneus longus is removed or a hematoma may form and lead to subsequent drainage. This occurred in one of our cases but since that time we have been cautious to control the bleeding thoroughly and no trouble has ensued. The patient may be allowed to walk on the foot in a week or ten days following operation.

The tabulation gives the pertinent facts concerning the patients who have been discussed in this series. I believe it is self explanatory and needs no further comment.

COMMENT AND SUMMARY

Much has been written on the cause and cure of recurrent dislocation of the shoulder. Bankart apparently has described the pathologic condition which underlies these recurrent dislocations and he has devised a sound operation based thereon. His operation is formidable however as is also that put forward by Galie and LeMesurier. If regardless of the underlying pathologic change certain simpler operations will give as good results I believe they should not be discarded. The teno suspension operation in a closely followed series of cases (fifty one patients fifty five operations) in which sufficient time has elapsed to determine reasonably the end results gave cure in 91 per cent.

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THE ETIOLOGY AND TREATMENT OF PAINFUL HIPS AMONG ADULT PERSONS

RALPH K. GHORMLEY

The various efforts to develop methods of treatment of painful hips among adult persons have brought to many a realization of the fact that in most cases this condition is based on some pre-existing disease process or injury. In years past hips so involved have been called hypertrophic hips or *malum coxae senile* with little or no thought as to the etiology. In many of these cases scrutiny of the patients and more careful inquiry into their histories will reveal the etiologic factor. In other cases it will be impossible to learn anything of significance from the history as to the etiology of the condition.

GENERAL CONSIDERATIONS

It must be remembered that the hip joint is a nearly perfect hemispherical surface. Its smoothness and integrity are important in the maintenance of normal function. Irregularities in the shape and surface of the joint may not cause any notable disturbance in the function of the joint at the time of their occurrence. It must be remembered however that even small abrasions and defects in the surface of joints which cause damage to the articular cartilage are not likely to be repaired perfectly so that an irregularity arises which may in time by erosion of its opposing surface cause extensive fibrillation of the articular cartilage. Eventually such fibrillated cartilage becomes thinned and beneath it are developed a thickening and exostosis of the bone with marginal hypertrophic changes the characteristic pathologic changes of osteoarthritis of the hip. As time goes on these changes become more marked and a vicious circle is established so that ultimately the movements of the hip are limited and painful. It may be years from the time of the first damage to the joint surface until the stage of pain is reached and often the patient may be relatively comfortable for several years more before the pain and limitation of motion becomes so marked as to cause a noticeable disability.

This is partly due to the fact that one may will sit and stand without actually moving the hip joint through any appreciable range of motion. That is to say the person who knows that his hips are painful learns to will and go about his work without moving the hips normally. By thus protecting them, he can go about without any severe degree of pain and maintain himself for a long time with only a minimal degree of discomfort.

If one accepts these facts which are obviously the underlying causative factors in many cases of painful hips one must realize the inevitable results which must develop in such cases. In many instances a recognition of the importance of the underlying factors will help to prevent such painful and disabling developments. Such conditions as slipped epiphyses can be more accurately reduced and congenital dislocation of the hip can be more carefully reduced so that changes in the contours of the head of the femur and in the acetabulum which would lead to subsequent traumatic arthritis and ultimately to painful adult hips will not be produced. Legg Perthes disease can be recognized earlier and treated more effectively so that the severe deformities of the head of the femur which may result from untreated Legg Perthes disease can be prevented.

In order to review more in detail some of these conditions and point out their results we will discuss the conditions separately.

PAINFUL ADULT HIPS RESULTING FROM INFECTIONS OF INFANCY AND CHILDHOOD

In general one of three things can happen to a hip as the result of suppurative arthritis. First complete destruction of the capital femoral epiphysis may occur with subsequent sequestration which necessitates removal of the epiphysis or the epiphysis may ultimately absorb or become revascularized. Usually in these cases a rather marked degree of fibrous ankylosis takes place and oftentimes shortening of 2 or 3 inches (5 or 8 cm) of the extremity may result in adult life. Second dislocation may occur being caused by either stretching of the joint capsule or partial destruction of the acetabulum by the infection. Hips so affected usually become adducted, limited in movement and painful. Third ankylosis may take place although this is probably rare as a result of infections in infancy.



Fig 248 — Hip of a child following an acute mild febrile reaction of the painful hip which because of its mildness was thought to be bursitis rather than pyogenic infection. In *b* same patient six years later showing hypertrophic changes around head of right femur and acetabulum the result of reaction to damage done at time of infection six years earlier.

for the head of the femur at such a time is almost entirely cartilaginous so that one or the other of the first two effects previously mentioned is likely to be produced. In many cases,

However the head of the femur may be only partly damaged and a deformity may result which will lead to hypertrophic changes later on in life

The results of infections in childhood are similar to those produced by infections in infancy except that destruction and



Fig 49—Hip of a young woman, aged twenty years. Hypertrophic changes without ankylosis which were residual from suppurative arthritis eight years previously may be noted

sequestration of the entire epiphysis occurs less commonly in childhood (Fig 248 *a* and *b*) than in infancy. The damaged femoral head which leads to subsequent hypertrophic changes is more often seen in childhood than in infancy, and ankylosis may result more often from such infections when the hyaline articular cartilage is destroyed. Of course an ankylosed hip is

not a painful hip and if it happens to be ankylosed in a favorable position with only slight flexion deformity and in about the neutral position of abduction or adduction it is not a serious handicap. Incomplete ankylosis often will lead to a painful condition later in life (Fig. 249) and will require surgical treatment which oftentimes must be arthrodesis (Fig. 250 *a* and *b*). Ankylosis of a hip in a faulty position at times may lead to painful conditions of the opposite hip and to chronically painful conditions of the lower part of the back for that reason.



Fig. 250—In complete ankylosis from suppurative arthritis in childhood *a* before operation hip as painful *b* after arthrodesis.

osteotomy is required for correction of the position or arthroplasty is needed for restoration of motion of the hip.

Tuberculosis of the hip rarely seems to result in a hip of the type which leads to *malum coxae senile*. Hips so affected usually are so completely destroyed that a wandering type of acetabulum results with marked flexion adduction deformity and severe shortening of the limb (Fig. 251). In view of the decrease that has been obtained in the incidence of tuberculosis and the tendency to produce bony ankylosis by surgical means it would seem that many less adult persons with painful hips caused by tuberculosis will be seen in the future unless there

is a drastic trend upward in the incidence of tuberculosis arising from world wide wartime conditions



Fig 251.—Old tuberculous hip with complete destruction of acetabulum and head and neck of femur. Ankylosis has not occurred. Hip was painful but malum coxae senile was not present.

PAINFUL HIPs RESULTING FROM LEGG PERTHES' DISEASE

Legg Perthes disease is a condition of early childhood involving the capital femoral epiphysis. A type of aseptic necrosis or fragmentation takes place and proceeds through a definite cycle, leaving the femoral head intact but usually in a broader, flatter shape than is normal. The amount of flattening and broadening is variable but when the disease is more extreme a rather severe degree of traumatic arthritis develops so that the development of osteoarthritis in later life is almost inevitable (Fig 252). The early hypertrophic changes may not be noticeable, so far as symptoms are concerned until the third or fourth decade has been attained and then with a mild traumatic sort of pain on activity the symptoms begin. These lead to more severe symptoms later in life and usually to limitation of motion and disability. Hips so affected are typical of those under con-

not a painful hip and if it happens to be ankylosed in a favorable position with only slight flexion deformity and in about the neutral position of abduction or adduction it is not a serious handicap. Incomplete ankylosis often will lead to a painful condition later in life (Fig. 249) and will require surgical treatment which oftentimes must be arthrodesis (Fig. 250 *a* and *b*). Ankylosis of a hip in a faulty position at times may lead to painful conditions of the opposite hip and to chronically painful conditions of the lower part of the back for that reason.



Fig. 50—In complete ankylosis from suppurative arthritis in childhood *a* before operation *b* as painful *b* after arthrodesis

osteotomy is required for correction of the position or arthroplasty is needed for restoration of motion of the hip.

Tuberculosis of the hip rarely seems to result in a hip of the type which leads to *malum coxae senile*. Hips so affected usually are so completely destroyed that a wandering type of acetabulum results with marked flexion-adduction deformity and severe shortening of the limb (Fig. 251). In view of the decrease that has been obtained in the incidence of tuberculosis and the tendency to produce bony ankylosis by surgical means it would seem that many less adult persons with painful hips caused by tuberculosis will be seen in the future unless there

surgical treatment such as either a cup arthroplasty or re arthrodosis is necessary

PAINFUL HIPs RESULTING FROM SLIPPING OF CAPITAL FEMORAL EPIPHYSIS

This condition is characterized by gradual or sudden displacement of the capital femoral epiphysis of children who usually are between the ages of ten or eleven and fifteen years. Since



Fig 753—Hip showing early hypertrophic changes due to slipping of the capital femoral epiphysis

the onset oftentimes is insidious the condition is not recognized in some instances until it has become advanced. If the condition is not treated a severe deformity of the head of the femur results and it is as a rule inevitable that hypertrophic changes take place and malum coxae senile develops. These are more

likely to develop earlier in life than is hypertrophic arthritis arising from Legg Perthes disease because a deformity of the femoral head in a severely displaced epiphysis occurs early and is marked (Fig 253) In those cases in which displacement is less severe and in those in which complete and accurate restoration of the epiphysis has not been accomplished by whatever means has been used a slower change takes place and often the end result is a less severe deformity of the femoral head and a much less severe type of hypertrophic arthritis

As a preventive measure the most important single factor is early recognition of the true nature of the condition in these cases in which there is an insidious onset so that proper treatment can be carried out and deformity of the femoral head can be prevented Once slipping has taken place the most nearly accurate replacement possible of that slipped epiphysis must be carried out and weight bearing must be prevented until the epiphyseal line is closed By this means mechanical changes between the articular surfaces are prevented and traumatic arthritis is avoided But once the condition has become established if symptoms are severe enough treatment should follow the same lines as that outlined for hypertrophic arthritis which is the result of Legg Perthes disease

PAINFUL HIPS RESULTING FROM OLD INJURIES TO THE JOINTS

Various sorts of injuries to the hip joint may occur usually they are severe enough to cause some transient symptoms but not severe enough to cause fracture or dislocation of the joint Such injuries at the time of infliction no doubt cause a crack through the articular cartilage or some degree of damage to the articular surface which is sufficiently severe to cause a scar on the surface of the joint Reaction about this site of damage brought about by motion or repeated use may in time result in formation of enough excess osteoid tissue and scar tissue to make the joint function abnormally (Fig 254) The time interval in such cases is no doubt long and in many instances the changes do not reach the stage at which symptoms are produced

Some years ago I heard a paper read by the late Murk Jansen of Leyden Holland on the subject Nippings of the Round Ligament I have been unable to find any reference to a published article by him under that title but as years have gone

by I have been led to believe that his theory probably accounted for some instances of hypertrophic arthritis of the hip. As the result of slight injuries the round ligament may gradually become scarred, so that it enlarges and so that enough tissue is produced to initiate some mechanical changes in the adjustment of the articular surfaces. As maladjustment of these sur-



FIG. 254.—Hypertrophic changes about hip in woman who injured the hip four years previously but did not have demonstrable fracture or dislocation.

faces occurs additional traumatic changes take place until in time definite hypertrophic arthritis is established.

Such conditions as the aforementioned one are hard to foresee. Only by the most careful examination can unusual changes such as the ones described be detected. One may at times suspect them when slight limitation of passive movement of a hip is encountered. When symptoms are persistent, limitation of

activity may be prescribed although by the time definite persistent symptoms have become established the condition has evolved into one of hypertrophic arthritis and is well beyond the stage at which prophylactic measures can be carried out.

The same condition may follow more severe injuries such as either fractures of the head of the femur or fractures of the



Fig. 255—Severe fracture of acetabulum in adult. Painful hypertrophic arthritis had developed so that arthrodesis was necessary.

acetabulum. In such cases damage to the articular surfaces of the femur and acetabulum usually is severe and unless restoration of these surfaces is complete some degree of mechanical maladjustment will take place and hypertrophic arthritis will gradually develop (Fig. 255). In such cases the orthopedic surgeon may be disappointed when after he thinks he has accomplished perfect reduction he finds that a change has gradually occurred which will lead to painful symptoms in that hip.

For this reason it is well to be guarded in arriving at or announcing the prognosis of the long range functional results in such hips.

Such changes as those described often take place even in those cases in which reduction apparently has been perfect, and they cannot be prevented in some instances. However I believe it is well in such cases to prevent weight bearing for a long time after the injury has taken place. Articular repair proceeds slowly, and unless the joint surface is given every chance to repair itself irregularities in the contour will result which will lead to the gradual onset of hypertrophic changes and symptoms ultimately will develop.

In such instances again the preventive treatment, in so far as a preventive treatment can be outlined is accurate reduction and a long period of nonweight bearing designed to allow complete healing of the surfaces before function is recommenced. Again the treatment once the arthritic condition is established is the same as that described for painful hips resulting from Legg Perthes disease or slipped epiphysis.

Hypertrophic changes may and often do follow instances of *aseptic necrosis of the femoral head*. Aseptic necrosis was described by Phemister in 1934 and it has become widely recognized since that time.¹ In this condition part or all of the head of the femur undergoes necrosis arising from loss of blood supply secondary to injury. As a rule the blood supply gradually returns and with its return deformation of the head of the femur results so that irregularity of the contours of the head develops. In the presence of faulty apposition between the femoral head and the acetabular surfaces hypertrophic changes result which in time inevitably will lead to the production of symptoms.

Such aseptic necrosis may follow trauma with or without fractures. It may follow fracture even when apparently perfect reposition of the fragments has been accomplished or it may follow traumatic dislocation in which perfect reduction has been achieved. It is insidious in onset and often fully developed before it is recognized. It may develop or at least symptoms of it may develop a year or two after the inciting injury. For this reason in such cases prognosis as to ultimate function should be guarded. If the slightest evidence of aseptic necrosis appears limitation of activity and even the use of crutches

without weight bearing should be prescribed and in many instances the subsequent changes can thus be minimized. Various efforts to re-establish circulation in the affected part of the head of the femur have been made with indifferent and inconclusive results. Protection against weight bearing is the most important form of treatment known to date.

PAINFUL HIPS RESULTING FROM CONGENITALLY INADEQUATE ACETABULUM

The whole subject of this condition has been brought up to date by Hart in a paper recently published. It is a condition recognition of which is slowly creeping into the orthopedic literature. Its relationship to congenital dislocation of the hip and to osteoarthritis is clearly set forth in Hart's article. It may be said briefly that certain persons are endowed with an inadequate socket which in some instances is so completely inadequate as to produce congenital dislocation of the hip. Other terms used to describe the condition were enumerated by Hart as dysplastic acetabulum, hip dysplasia without dislocation, preluxation, potential dislocation, incompetent acetabulum, flat socket and subluxation. Hart used the term primary genetic dysplasia of the acetabulum. Another term occasionally seen is flat socket (Fig. 256 a).

In cases in which congenital dislocation does not develop the inadequate acetabulum because of its obvious mechanical disadvantage leads to the gradual onset of traumatic arthritic changes which later become symptomatic, the end effect being true hypertrophic arthritis. Such a process like many of the others described herein is very gradual and years are required for it to develop (Fig. 256 b). In cases in which such shallow acetabula are not recognized by roentgenographic examination symptoms do not as a rule develop until the patient has reached adult life, often in fact symptoms do not arise until the patients are well toward middle life. In instances in which there is a dislocation of one hip the inadequacy of the acetabulum on the opposite side often will be noted. It is rare, however, that a congenital inadequate acetabulum will be recognized among younger people for there is no symptomatology that is characteristic of the condition until some of the arthritic changes have developed. I think it is important, however, that roentgenograms of the pelvis which will show the hips be made

for patients who have mild, transient symptoms such as those of pain or limp or limitation of motion. In this manner conditions amenable to treatment will be revealed and something can be done to prevent the almost certain severely painful condition that will develop later in the patient's life.



Fig 256—Inadequate acetabulum *a* of a young adult woman which was beginning to cause symptoms this condition certainly will lead to hypertrophic arthritis later in life *b* bilateral with superimposed bilateral hypertrophic changes such hips are very painful in late adult life

In cases in which such an acetabulum is discovered early two courses of treatment are available. In the first type the patient is cautioned against strenuous activities and sports which exert great strain on the hip. It is advised not to become overweight and is warned to rest the hip at the slightest sign of any pain.

or symptom referable to the hip. By means of such a program surgical procedures can be avoided in some cases but in most instances symptoms will develop which in time will become severe. In cases in which the patient is experiencing frequent premonitory symptoms and in fact probably in all cases some type of shelving operation should be performed. It is not my purpose to discuss herein the merits or demerits of various types of shelving operations. I do believe however that in cases in which this condition is recognized early much trouble can be prevented by the surgical construction of an adequate shelf so that the acetabulum is deepened and erosion on the head of the femur which marginal weight bearing ultimately causes is prevented. After such erosion has begun complete restoration of the hip to normal is very difficult. The surgeon can however by construction of a good shelf so change the mechanical relationships about the hip as to minimize the symptoms.

PAINFUL HIPS ARISING FROM CONGENITAL DISLOCATIONS

Congenital dislocations contribute their share to the production of the painful hips in question. This statement refers not so much to congenital dislocations that have not been reduced as to those that have been reduced. In congenital dislocations of hips that have not been reduced hypertrophic changes usually do not develop. Occasionally pain may be caused by such hips but as a rule the pain arises from strain on the ligamentous structures that hold the hip together (Fig. 757). In cases in which a false acetabulum has developed painful hips may and do at times occur. In these cases the factors contributing to the painful condition are similar to those causing such conditions in cases of congenitally inadequate acetabulum. When a false acetabulum has developed it means that an inadequate acetabulum has been formed as in congenitally inadequate acetabulum and the mechanical relationships of head to acetabular surface are so disturbed as to set up a process of traumatic arthritis and ultimately hypertrophic arthritis develops.

On the other hand in the case of the reduced congenital dislocation of the hip other factors are present. Two or three generations ago the manipulative procedures by means of which congenital dislocations were reduced were much more violent than those used today. Trauma to the femoral head and ace

tabulum was exerted in such a manner that it was not infrequent to see changes in the shape of the femoral head such as are seen in Legg Perthes disease. The subsequent changes likewise were the same and hypertrophic changes frequently resulted (Fig 258). Incomplete reduction as well as frequently repeated reduction left traces of trauma that in time would lead to per



Fig 57—Congenital dislocation of hip of a young adult woman condition was painful but hypertrophic changes had not occurred

manent changes in contour such as have been mentioned previously herein. Thus many factors in cases of congenital dislocation of the hip may contribute to the causation of such lesions. As a prophylactic measure the most important point to be stressed is the early recognition of congenital dislocation of the hip followed by the most gentle and complete reduction of the

dislocation. Despite the fact that it may seem radical in many instances the most gentle and most complete reduction can be accomplished by open operation when it is done by a surgeon skilled in that manner of treatment.



Fig. 238—Reduction of congenital dislocation of hip many years previously. Hip was painful.

PAINFUL HIPS ARISING FROM OTTO PELVIS

Another type of lesion which although it is not seen frequently nevertheless contributes a considerable number of cases to those included in the title of this paper is the so called Otto pelvis or intrapelvic protrusion of the acetabulum. This condition is characterized by a variable degree of deepening of the acetabulum and according to Pomeranz this deepening may arise from either an infection in the acetabulum in the course of which the floor of the acetabulum has become weak.

ened and in which subsequent intrapelvic protrusion of the acetabular floor has taken place or from some malacic disease involving the bone about the hip joint in the course of which gradual sinking in of the acetabular floor has occurred. In any case once the deepening has been established a mechanically imperfect hip joint results and it is almost inevitable that in time secondary hypertrophic changes will take place which will result in further limitation of the motion of the hip joint thus setting up a vicious circle which will lead to the condition under consideration (Fig. 259).



Fig. 259—Bilateral Otto pelvis or intrapelvic protrusion of acetabula. Hypertrophic changes already are showing on right side.

What to do to prevent this is again a problem. At the Clinic in our hands acetabuloplasty has not been satisfactory and we believe that arthroplasty of the cup type with wide resection of the anterior margin of the acetabulum offers the most relief in these cases.

Symptoms may develop at varying ages of the patients. I have seen them develop among persons as young as to be in the third decade but for the most part they will not be encountered until the fifth or sixth decade of life. When the condition is

more severe arthrodesis may be necessary but when the disease is bilateral this procedure is contraindicated unless mobilization of the other hip can be carried out. In many cases the condition is bilateral and this fact must always be taken into consideration in the planning of treatment.

PAINFUL HIPS ARISING FROM OSTEOCHONDRITIS DISSECANS

This condition rarely affects the head of the femur but I have seen it do so occasionally with the result that a traumatic type of arthritis develops in the hip joint. Osteochondritis dissecans usually is a disease of adolescence or at least in most instances the underlying pathologic changes take place during the time of development of the epiphysis. There are instances however in which the condition does not become symptomatic until the patient has reached adult life and this is perhaps more true of those cases in which the hip is affected than it is of cases in which the knee joint is involved. I have seen a patient who had what seemed to be underlying Legg Perthes disease with complicating osteochondritis dissecans. Until the etiology of the condition is thoroughly understood it may be useless to argue about causes and profitable only to point out the effects of the condition. These seem to me to be an almost invariable change in the contour of the head of the femur with the final result the same as in the other cases previously considered—definite hypertrophic arthritis.

So far as preventive treatment in these cases is concerned early recognition of the condition is perhaps most important to be followed by removal of loose bodies when these are found. In cases in which no loose body has been found and in those in which the condition is found to be in an early stage conservative treatment consisting of prevention of weight bearing by means of the use of crutches for many months sometimes will produce spontaneous healing with lessening of the arthritic changes.

PAINFUL HIPS RESULTING FROM OSTEOCHONDROMATOSIS

This condition is perhaps even more rare than osteochondritis dissecans but it does occasionally involve the hip and as a rule will lead to the development of changes which in the long run will produce hypertrophic arthritis (Fig. 260). In the presence of synovial osteochondromatosis multiple loose osteo

cartilaginous bodies are found within the joint and they act as foreign bodies or loose bodies do in any joint. Repeated minute trauma to the articular surfaces take place and as this trauma is inflicted a traumatic type of arthritis is started. If this process is not halted severe hypertrophic arthritis may and often does develop in the joint.

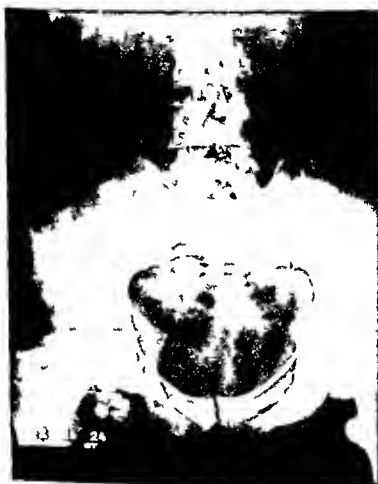


Fig. 260.—Hip joint showing hypertrophic changes secondary to a synovial osteochondromatosis. large group of osteocartilaginous loose bodies present.

As a prophylactic measure therefore surgical removal of loose bodies in the joint should be carried out in cases of osteochondromatosis of the hip joint. Such a procedure may not always be simple and there may be recurrence of the loose bodies in which instances repeated removal should be carried out because if this is not done it is almost certain that arthritis will develop which will lead to a severely crippling deformity.

of the hip. No medical treatment that I know of will do anything toward preventing the formation of loose bodies in synovial osteochondromatosis.

PAINFUL HIP RESULTING FROM OTHER TYPES OF ARTHRITIS

Although it is not very common to see hypertrophic arthritis develop as a sequel to infectious arthritis, hypertrophic arthritis may occasionally occur among adult persons. Septic arthritis of a low grade of virulence, chronic infectious rheumatoid arthritis and spondylitis deformans may leave a hip joint without ankylosis but with so much damage to the joint surface that hypertrophic changes develop and the usual chain of events follows.

In cases of monarticular involvement, arthrodesis may be the procedure of choice if pain is severe. As is true in other cases, however, I believe that in monarticular involvement performance of cup arthroplasty should be considered.

SUMMARY

A group of conditions involving the hip joint which I believe may contribute toward the development of hypertrophic changes has been reviewed and in this review the development of the painful conditions of the hip known as osteoarthritis, malum coxae senile, hypertrophic arthritis, degenerative arthritis and others has been set forth. The condition of painful hips among adult persons, as I have tried to point out, has an insidious onset; often it arises from some obscure pre-existing trauma or lesion. This review has been presented with the hope that earlier recognition of these pre-existing lesions and more effective treatment of them will be achieved so that this process, which inevitably leads to the final painful conditions outlined herein, can be minimized or even halted.

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A COMPARATIVE STUDY OF SEVERAL METHODS OF TREATMENT OF FRACTURES OF THE SHAFT OF THE TIBIA

H HERMAN YOUNG and JACK S BLAISDELL

REVIEW OF THE LITERATURE

In 1934 Ostermann reviewed the records of a small series of fractures of the tibia. The main purpose of the review was to compare the healing time of the fractures according to the type of treatment they had received. In thirty four cases in which the fracture was treated by manipulation and immobilization in plaster casts it required five to five and a half weeks to consolidate, in ten cases in which it was treated by traction it required eight to fifteen weeks in five cases in which it was treated by operative methods it required eighteen to twenty eight weeks for union to take place. Ostermann thus concluded that early reduction of the fracture followed by immobilization in a plaster cast was the best method of treatment.

In 1938 Linden made a comparative study of the records of oblique fractures of the shaft of the tibia when treated by osteosynthesis by means of metal screws by osteotraction or by reduction and cast. He concluded that the best results as regards both the period of repair and the end result were obtained in the group in which osteosynthesis was performed. Linden's series was much larger than Ostermann's for it contained sixty seven cases in which osteosynthesis was performed fifty cases in which the fracture was treated by traction and forty seven cases in which it was treated by manipulation and fixation in a cast. Good results were obtained in 90 per cent of the cases in which osteosynthesis was performed. The average stay in the hospital was seventy two days and the average interval during which the patient was incapable of resuming his occupation was 5.2 months. In the cases in which the fracture was treated by traction the stay in the hospital averaged eighty days the patients were incapacitated for six and a half months and good results were obtained in 82 per cent of the cases. In the cases

in which the fracture was treated by cast alone or by manipulation and cast good results were obtained in 87.7 per cent of the cases the stay in hospital averaged fifty eight days and the patients were incapacitated for five months. However in forty seven cases in which operation was performed immediately after the injury the duration of stay in the hospital was reduced to sixty three days and the average disability lasted only 4.7 months. Thus Linden concluded that if the operation were performed immediately by a competent surgeon in a well equipped hospital the end results would be better and the period of repair shorter than by treatment with either traction or immobilization in a cast and this in spite of the fact that in the cases in his series in which the fracture was immobilized in a plaster cast the condition was generally milder than in cases in which other forms of treatment were used.

Hudack in an analysis of the records of eighty two cases in which fractures of the tibia of adult patients were treated in the ten year period 1929 to 1938 inclusive concluded that the operative treatment offers a surer course and better results than do the nonoperative methods. The healing time was shorter for those patients surgically treated provided there was not a delay of several days or more between the injury and the operation. Hudack stated that in a case in which simple fracture is treated early with rigid internal fixation the period of hospitalization may be only two weeks with protected bearing of weight expected in one to two months and solid bony union within four months.

Mansfield reviewed the records of a series of fifteen fractures of both bones of the leg treated in 1939 in the United States Marine Hospital Detroit Michigan. He found that the average stay in the hospital was 2.8 months for patients treated by closed reduction but only 1.1 months when the open method was used. Likewise the average time from injury to ambulatory status was 5.7 months for patients treated by closed reduction compared with 7.9 months for those treated by open reduction. Patients treated by closed reduction lost an average of 6.8 months from work while those treated by open reduction returned to work in 4.8 months. There were 43 per cent of poor clinical results and 57 per cent of complications in the group in which closed reduction was performed compared with no poor results and no complications in the group in which opera-

tive methods were used. Figuring at the World's Progress Administration's base pay level of \$57.20 per month for common labor, Mansfield then concluded that an open reduction saved the patient \$114.40 by shortening his time lost from work. On the basis of \$3.75 per bed per day as the cost to the hospital, there was a saving of \$192.45 when an open reduction was performed. While this series is small, its implications are great for if a total saving of \$306.85 per patient is made possible by using a method of treatment which produces better results, then this method should be adopted.

BASIS OF OUR STUDY

As with the previous authors, the purpose of our recent study of fractures of the shaft of the tibia was to compare the results of treatment by manipulation and fixation in a cast with those of the methods of traction and open reduction. For this study, the records of all fractures of the shaft of the tibia that were observed and treated at the Clinic from 1930 through 1940 were reviewed. Tibial plateau fractures, fractures involving the ankle joint, and all pathologic fractures were excluded from our series. Also excluded were those cases in which the follow-up study was not adequate for us to be reasonably certain of the end result. The presence or absence of an accompanying fracture of the fibula was not considered in our tabulations of the final result except to note that in 139 of the cases both bones were fractured.

CRITERIA FOR THE JUDGMENT OF END RESULTS

In making a study such as this, one is confronted immediately with the establishment of certain criteria by which the end results may be judged. Many and varied are the complications of fractures and such complications may be present from the time of the injury or arise during the course of treatment. If in the end, however, union without deformity and with good motion of the joints was obtained, the result was counted as good. Malunion, nonunion, death, amputation, or the presence of persistent infection was counted as a poor result. For those cases in which union was obtained, we attempted to decide the time interval that elapsed between the original injury and the presence of union. Establishing the time when union is complete is a difficult problem and one which cannot be met accurately. For the pur-

averaged five weeks in obtaining union the average time for this group was eight weeks and four days. Union occurred more rapidly in the fracture situated toward either end of the bone than in those toward the middle of the bone. Approximately half of these patients did not have any displacement of their fractures and were treated simply by the application of a cast. The remaining patients had a manipulation of their fracture prior to application of a cast with the exception of one patient who was treated by traction.

Six patients in the children's group having simple acute fractures were treated by open reduction and internal fixation by means of beef bone screws, Parham bands or metal plates (Table 1). Operation was performed on three of these patients because it was necessary to secure and maintain reduction by the closed method and on three because of the severity of the fracture. In this group obtained a good result. One fracture involved the middle third of the tibia, two were of the middle third one at the junction of the middle and lower third and two in the lower third alone. The average healing period for this group was twelve weeks and four days or approximately 100 per cent by the closed method.

tive methods were used Figuring at the Works Progress Administration's base pay level of \$57.20 per month for common labor Mansfield then concluded that in open reduction saved the patient \$114.40 by shortening his time lost from work. On the basis of \$3.75 per bed per day as the cost to the hospital there was a saving of \$192.45 when an open reduction was performed. While this series is small its implications are great for if a total saving of \$306.85 per patient is made possible by using a method of treatment which produces better results then this method should be adopted.

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pose of our comparisons we arbitrarily selected the date of union as being that day on which union was felt to be present both clinically and roentgenographically and when unguarded bearing of weight was begun. The fact that nonunion or refracture did not develop in any of our cases after this date but instead the anticipated result was obtained would seem to indicate that union was complete or at least fairly complete at that time. Some of the surgeons were more cautious than others in advising weight bearing but in the several groups studied these differences of treatment offset one another. Likewise the presence of accompanying injuries which delayed weight bearing was also fairly well neutralized in each group.

ANALYSIS OF END RESULTS IN 166 FRACTURES TREATED BY SEVERAL METHODS

Our entire series comprised a group of 166 fractures occurring among 164 patients, two of the patients having bilateral tibial fractures as well as other injuries. These patients were first divided as to their ages, the first group containing all children up to and including sixteen years of age, the second group containing all patients more than sixteen years of age. The fractures were then grouped as being either simple or compound, acute or subacute. In the acute category were placed all of those cases in which the patients received their initial treatment at the Clinic within the first forty-eight hours after the injury. All cases in which the patients were seen and treated after the first forty-eight hours and up to and including twenty-eight days after the injury were placed in the subacute group. It was felt that such a division of cases was necessary in order to evaluate the various methods of treatment.

Simple Acute Fractures in Children—Among children there were thirty-four simple acute fractures treated by closed reduction, all obtaining a good result (Table 1). Four of these fractures were of the greenstick type, seven transverse, six comminuted, fourteen spiral and three spiral and comminuted. Twenty-two of these fractures involved the lower third of the shaft, one was in the upper third, six were in the middle third, four were at the junction of the middle and lower thirds and one was at the junction of the upper and middle thirds. In this group the average time in which union took place was eight weeks and one day. Excluding the greenstick fractures which

	3	0	0	0	4 wks 1 day	10 wks 6 days	8 wks 4 days
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averaged five weeks in obtaining union the average time for the group was eight weeks and four days Union occurred more rapidly in the fracture situated toward either end of the bone than in those toward the middle of the bone Approximately half of these patients did not have any displacement of their fractures and were treated simply by the application of a cast The remaining patients had a manipulation of their fracture prior to application of a cast with the exception of one patient who was treated by traction

Six patients in the children's group having simple acute fractures were treated by open reduction and internal fixation by means of beef bone screws Parham bands or metal plates (Table 1) Operation was performed on three of these patients because of failure to secure and maintain reduction by the closed method and on three because of the severity of the fracture All of this group obtained a good result One fracture involved the upper third of the tibia, two were of the middle third one was at the junction of the middle and lower third and two involved the lower third alone The average healing period for this group was twelve weeks and four days or approximately four weeks longer than by the closed method

Simple Subacute Fractures in Children—The foregoing situation was reversed in favor of open reduction of simple fractures among children when the delay of treatment was more than forty eight hours These subacute groups were small however and perhaps too small to allow any conclusion Seven patients were treated by fixation in a cast and of these only one required manipulation prior to application of the cast (Table 2) No patients were treated by traction All of these patients obtained a good result The average healing period was ten weeks and four days when the greenstick fractures were eliminated Likewise all of these fractures were in the middle or lower half of the tibia and the same was true of those treated by open reduction with beef bone screws Parham bands or metal plate fixation Only three patients in this subacute group were treated by open reduction (Table 2) Again all obtained a good result The healing period was eight weeks and four days two weeks shorter than that of the group treated by closed methods

Simple Acute Fractures in Adults—Forty eight simple acute fractures among adults were treated by closed reductions forty

TABLL 2
SIMPLE FRACTURES AMONG CHILDREN SEEN THREE TO TWENTY EIGHT DAYS AFTER INJURY

Type	No	Result		Healing Period							Total average	
		Good	Poor	Up ‡	Up mid	Mid	Mid low	Low ‡	Average			
Closed Reductions												
Greenstick	2	2	0			0	4 wks 5 days	No record	4 wks 5 days	4 wks 5 days		
Transverse	3	3	0			11 wks 6 days	19 wks 3 days	5 wks 2 days	12 wks 1 day	12 wks 1 day		
Comminuted	1	1	0			12 wks	0	0	12 wks	10 wks 4 days		
Spiral comminuted	1	1	0			4 wks	0	0	4 wks			
Total	7	7	0			9 wks 2 days	12 wks 1 day	5 wks 2 days	9 wks 4 days			
Open Reductions												
Transverse	1	1	0	0	0	4 wks 1 day		0	4 wks 1 day			
Spiral	2	2	0	0	0	0		10 wks 6 days	10 wks 6 days			
Total	3	3	0	0	0	4 wks 1 day		10 wks 6 days	8 wks 4 days			

Typ	No	R ult		T Not d	B ling Period						
		G d	Poor		Up t	M d	M d l v	Lo t	Up & Lo	Up & M d	A er ge

Cl d R d t om

Trans ree	9	8	1	0	18 l 1 d y	14 wks 1 d y	16 ks 1 day	0	0		15 l 5 day
Comm n t d	21	20	0	1	16 l 3 d ys	12 l 3 d ys	16 l	15 wk 2 days	26 l 6 d ys		15 l
Sp ral	13	12	0	1	0	31 k 1 day	0	17 ks 5 day	0		18 l 6 d ys
Sp al c mir nuted	5	5	0	0	0	13 ks	21 l 5 d ys	12 l 4 d ys	0		19 ks 1 d y
T tal	48	45	1	2	16 wks d ys	15 ks 1 d y	17 wks 3 d y	16 k 3 d y	26 l 6 days		16 l 3 d ys

Open R d t r

Trans er	3	3	0	0	12 wks	20 l 4 days	14 l 2 days	0		0	15 ks 4 d y
Comm n t d	9	9	0	0	0	11 l	13 ks	15 ks 2 d y		5 l 5 days	12 ks
Sp l	6	6	0	0	0	0	12 wk 6 d y	1 wk 6 d y		0	17 wk 6 d ys
Sp ral mir ut d	8	8	0	0	0	11 k 6 d y	20 k 4 d y	17 wk 3 d y		0	17 l 4 d ys
T t l	26	26	0	0	12 wk	13 k 6 d y	16 wk 3 d y	13 wk 6 d y		5 wk 5 d y	14 k 5 d ys

six patients were traced (Table 3) There were forty five good results and only one poor result In this latter case the fracture became compounded in the cast and osteomyelitis developed at the site of the fracture Nine of these fractures were transverse twenty one comminuted, thirteen spiral and five spiral and comminuted The average healing period for the entire group was sixteen weeks and three days

In all of the twenty six cases in which simple acute fractures among adults were treated by open reduction a good result was obtained (Table 3) In thirteen or half of the entire number open reduction was performed because of a failure to reduce the fracture or maintain the reduction by the closed method In the other thirteen cases the open method was used primarily because of the severity of the fracture In this group the average healing period was fourteen weeks and five days or approximately two weeks shorter than in the similar group treated by the closed method Three of the fractures in this group were transverse nine comminuted, six spiral and eight spiral and comminuted

Simple Subacute Fractures in Adults—When treatment in the group of simple fractures among adult patients was delayed beyond forty eight hours there was a shift in favor of closed reductions Again however the groups are too small to permit the drawing of conclusions In only two of the four cases in which closed reduction was attempted could treatment by that method be used (Table 4) In the other two cases the open method had to be used in order to reduce the fractures In both of the cases in which the closed method was used however, the result was good The average healing period was thirteen weeks and four days In both of these cases the fractures were comminuted

In the group of seven subacute fractures among adults treated by open reduction two were comminuted four were spiral and one was spiral and comminuted (Table 4) In five of these cases a good result was obtained but in two nonunion developed One of these cases of nonunion was that of a syphilitic patient who persistently refused to follow antisyphilitic treatment and insisted on bearing weight on his leg against advice Possibly this case should be eliminated from the study but it is included as a failure in order to complete statistics The average healing period in this group in which open reduc

TABLE 4
SIMPLE FRACTURES AMONG ADULTS SEEN THREE TO TWENTY EIGHT DAYS AFTER INJURY

Type	R ult		H I G P r i			
	Good	P	Mid up	Mid lo	L f	L p d l o f
C l a s s i f i c a t i o n						
Comminuted	1	1	0	0	12 l 6 days	12 wks 6 days
Spiral comminuted	1	1	0	14 wks 1 day	0	14 wks 1 day
Total	2	2	0	14 l 1 day	12 wks 6 days	13 wks 4 days
O p e n P e d i c t a n						
Comminuted		1	1		0	17 l s 2 d y s
Spiral	4	3	1		19 l s 2 d y s	19 wks 2 day
Spiral comminuted	1	1	0		18 l s 2 d y	18 wks
Total	7	5	2		19 l s 2 d y	19 wks 4 d y s

TABLE 5
ACUTE COMPOUND FRACTURES SEEN WITHIN FORTY EIGHT HOURS AFTER INJURY

Procedure	No	Union	Nonunion	Infection	G-as Gangrene	Amputation	Death	Healing period
<i>Children</i>								
Closed reduction	3	3		2	0	0	0	17 wks 3 days
Open reduction (Karl chner wires)	1	1		1	0	0	0	47 wks 2 days
<i>Adults</i>								
Closed reduction	15	13	1	1	0	1	0	23 wks 1 day
Open reduction (plates etc)	14	9	1	8	3	3	7	25 wks 2 days
Primary amputation	2†							

Subsequently grafted and obtained union in 105 wks 6 days

† One amputation was performed for gas gangrene and one because of extent of injury

tion was performed was eighteen weeks and four days or approximately five weeks longer than the average of the two cases in which treatment was by the closed method

Acute Compound Fractures—It is practically impossible to draw any conclusion from the various groups of compound fractures as regards the healing period too many variable factors influence the result in each case. In spite of the occurrence of infection in two cases union occurred in all three cases in which acute compound fracture among children was treated by closed reduction (Table 5). The healing time was twelve weeks and three days. In only one case in this group was open reduction used. In spite of infection union occurred in this case in forty seven weeks and two days. In the similar group of adults fifteen patients were treated by closed and fourteen by open reduction (Table 5). In thirteen of the cases in which closed methods were used union was obtained with a healing period of twenty three weeks and one day. In one case of this group the extremity was amputated eventually because of the development of gangrene and in one case nonunion developed. Of the fourteen cases in which adult patients were treated by open reduction union was obtained in nine in twenty five weeks and two days. One patient died as the result of a pre existing pulmonary abscess and one died after amputation for gas gangrene. In two other cases the extremity was amputated in one case for gas gangrene and in the other because of severe osteomyelitis. In eight of the entire group infection developed. In the one case in which nonunion developed union was ultimately secured by aid of a bone graft.

Subacute Compound Fractures—In the groups of subacute compound fractures there were four cases in which children were treated by closed reduction (Table 6). In three cases union was obtained in nineteen weeks and five days. One patient was not traced. The one patient treated by open reduction obtained union in fifteen weeks and two days. In the group of subacute fractures among adults there was only one case (Table 6). In this case the fracture was treated by closed reduction but union was not secured until a bone graft was subsequently inserted.

Comment—From the foregoing resume of the findings of our study of the 166 tibial fractures it is hardly possible to state that either the closed or the open method of treatment will in

TABLE 6
COMPOUND FRACTURES SEEN THREE TO TWENTY EIGHT DAYS AFTER INJURY

Treatment	Children							Healing Period
	No	Union	Not Traced	Infection	Gas Gangrene	Amputation	Death	
Closed reduction	4	3	1	0	0	0	0	19 wks 5 days
Open reduction (Parham band)	1	1	0	1	1	0	0	15 wks 2 days
Primary amputation	1							
Adults								
Closed reduction	1	0†	0	0	0	0	0	0

Gas gangrene

† Finally secured union with bone graft after 122 weeks

fluence the healing period materially. The results have been good with each type of treatment. However, it must be pointed out that in those cases in which open reduction was used the injuries were generally more severe than in those in which closed reduction was used or else it was impossible to reduce the fractures by manipulation without resort to open reduction. Had all of the fractures in this series been treated solely by closed methods we are convinced that the results would have

TABLE 7
PERIOD OF HOSPITALIZATION DAYS

	Simple			Compound		
	Manipulation and Cast	Treatment	Open Reduction	Closed	Open	Treatment
<i>Children</i>						
Acute	42	56	85	20	124	0
	7					
Subacute	3	0	7	12	35	55
	7†					
<i>Adults</i>						
Acute	28	41	28	27.5	36‡	113
Subacute	17‡	0	36	108	0	0

Excluding further patients not remaining in hospital

† Excluding four patients not remaining in hospital

been disappointing. Correction of alignment is often impossible without open treatment and frequently this is the only method whereby intervening soft parts may be removed from the site of the fracture. Periods of hospitalization in the various groups have been fairly uniform (Table 7). The length of stay in the hospital of children who had simple acute fractures averaged seven days when they were treated by manipulation and cast and 8.5 days when the open method was used. In the group of subacute simple fractures the length of stay of the children

in the hospital averaged seven days each regardless of the manner of treatment. For simple, acute fractures among adult patients the length of stay in the hospital averaged four weeks regardless of whether the fracture was treated by the open or by the closed method. For adult patients who had subacute fractures the length of stay in the hospital averaged seventeen and a half days when the closed method was used and thirty six days when an open operation was performed. It was impossible to draw any conclusion as to duration of hospitalization in the groups in which the fractures were compound because there were so many variable factors.

CONCLUSIONS

As a result of our recent review of the records of 166 fractures of the shafts of the tibia we cannot say that open reduction will shorten either the stay in the hospital or the healing period. We do feel that the use of open reduction has greatly influenced the end results. In many cases the result would have been failure if open fixation of the fracture had not been used. There are of course some added risks when the operative method of treatment is chosen but when the operation is performed by a competent surgeon in a well equipped hospital these added risks become almost negligible. The use of this treatment may serve to change a difficult situation to a simpler one and to insure a better end result.

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AMPUTATIONS BELOW THE KNEE IN OCCLUSIVE ARTERIAL DISEASES

WILLIAM H. BICKEL

Many authors have dealt with the question of amputations and a new flurry of dissertations on this subject always appears with the advent of war. Much progress has been made in technic and selection of the site of amputations in cases in which amputation is occasioned by some type of trauma. However, when amputation is necessary because of infection or death of part of an extremity caused by deficiency of the vascular tree, the problem becomes a bit more complicated and the results of treatment are not as uniformly satisfactory. For this reason a summary and re-evaluation of the data and experience accumulated should be undertaken from time to time. With this thought in mind I have studied the cases in which amputation was performed below the knee at the clinic from January 1, 1930 to June 30, 1947 because of occlusive arterial disease. During this period 110 amputations were performed below the knee in 103 cases.

Included in this group were cases in which the volume of blood which nourishes the extremity had decreased permanently because of pathologic changes, namely cases of thrombo-angitis obliterans, arteriosclerosis obliterans with or without associated diabetes and acute arterial occlusions due to thrombosis or embolism. The last named may or may not be associated with thrombo-angitis obliterans or arteriosclerosis obliterans. It is unnecessary to dwell on the diagnosis of these conditions. As a group they present decrease in pulsations of the arteries of the extremity with the associated changes which would be expected. These changes vary from subjective coldness of the extremity to absolute loss of heat with complete ischemia. Pain may be present only when produced by the increased need for circulation in activity or be severe and constantly present as the limb becomes practically avascular. Ulceration, infection, gangrene, one or all may be present in varying degree. Con-

firmatory signs of rubor and cyanosis on dependency and blanching on elevation may aid in the diagnosis

The number of cases of various types and ages of patients in each group are shown in Table I. There were ninety four men and nine women.

TABLE I

AGE OF PATIENTS AND PATHOLOGIC CHANGES

Pathology	Patients	Age Years	
		Mean	Range
Thromboangiitis obliterans	5	40	21-67
Arteriosclerosis obliterans with diabetes	28	58	6-61
Arteriosclerosis obliterans without diabetes	16	62	48-80
Acute arterial occlusion due to embolism or thrombosis	7	5	41-69
Total	103	49	21-80

SITE OF AMPUTATION

The decision to amputate below the knee in occlusive arterial diseases of the extremities is a difficult one to make. At times the history may give an indication of the efficiency of the circulation in the limb and may lead the surgeon to amputate above the knee. Severe claudication and pain in the calf muscles are reasons for doubting the existence of adequate circulation below the knee.

The clinical appearance of the leg in the horizontal, vertical and dependent positions is of importance in indicating how far distally in the limb adequate circulation is present. This is exhibited by the degree of rubor and blanching which takes place. However, the difficulty lies in determining how much of the occlusion apparent on clinical examination is dependent on true arterial occlusion and how much is the result of vasospasm. Gangrene of a digit or a portion of the foot has been observed in cases in which it was possible to palpate a pulsating anterior tibial or a posterior tibial artery or both. In such a case conditions seem ideal for amputation below the knee; however, when the incisions are made, the muscles may be found to be white

AMPUTATIONS BELOW THE KNEE IN OCCLUSIVE ARTERIAL DISEASES

WILLIAM H. BICKEL

Many authors have dealt with the question of amputations and a new flurry of dissertations on this subject always appears with the advent of war. Much progress has been made in technic and selection of the site of amputations in cases in which amputation is occasioned by some type of trauma. However, when amputation is necessary because of infection or death of part of an extremity caused by deficiency of the vascular tree, the problem becomes a bit more complicated and the results of treatment are not as uniformly satisfactory. For this reason a summary and re-evaluation of the data and experience accumulated should be undertaken from time to time. With this thought in mind I have studied the cases in which amputation was performed below the knee at the clinic from January 1, 1930 to June 30, 1947 because of occlusive arterial disease. During this period 110 amputations were performed below the knee in 103 cases.

Included in this group were cases in which the volume of blood which nourishes the extremity had decreased permanently because of pathologic changes, namely cases of thromboangitis obliterans, arteriosclerosis obliterans with or without associated diabetes and acute arterial occlusions due to thrombosis or embolism. The last named may or may not be associated with thromboangitis obliterans or arteriosclerosis obliterans. It is unnecessary to dwell on the diagnosis of these conditions. As a group they present decrease in pulsations of the arteries of the extremity with the associated changes which would be expected. These changes vary from subjective coldness of the extremity to absolute loss of heat with complete ischemia. Pain may be present only when produced by the increased need for circulation in activity or be severe and constantly present as the limb becomes practically avascular. Ulceration, infection, gangrene, one or all may be present in varying degree. Con-

in errors in evaluation the color of the muscle, the quality and quantity of the bleeding at the time of operation and the age and general condition of the patient are as good an index of the chance of survival of a stump below the knee as any of the previously tried methods

In seventy seven of the cases on which this paper is based the surgeon made on the operative record a note concerning the prognosis for healing of the stump. In forty cases the stump was given a good prognosis for primary healing. In thirty one of these forty cases the prediction was fulfilled and in nine failures occurred. Of nineteen cases a fair or 50 per cent chance of healing was recorded. In eleven of these primary healing occurred and in eight it did not. In eleven of eighteen cases in which chances of primary healing were recorded as poor primary healing occurred and in seven it did not. The surgeon was correct in fifty three out of seventy seven cases in which his opinion was recorded the error was greatest when a pessimistic outlook was expressed.

At the Clinic the practice has been to make a primary flap closure of the stump below the knee when this site has been selected for amputation. Primary healing occurs in a sufficient number of cases in which amputation is done at this level to warrant a trial of this procedure rather than to undertake secondary closure or amputation below or above the knee which is necessitated by the guillotine type of amputation below the knee. It is an accepted fact that amputations below the knee are not attempted in cases in which surgical interference is necessitated by an acute spreading cellulitis or infection which does not respond to elevation rest chemotherapy and local heat. Therefore the risk of complications from infections is minimal. Primary healing fails in the majority of selected cases because of ischemic slough and the success of secondary higher amputation is not endangered by the primary closure of the stump below the knee.

The eventual extent of vascular occlusion in thrombo angitis obliterans cannot be accurately predicted. Since this disease occurs in the active productive period of life it is important that the stump and prosthesis be as efficient as possible. These persons are faced with the possibility of an amputation of the opposite limb the level of which is undetermined. If a functioning knee can be secured after one of the two amputations this frequency

muscle flap leading out the lateral angle of the wound in cases in which hemostasis is not complete or infection is feared. In most cases the wound is closed without drainage. If drainage is necessary the drain is removed between thirty six and forty eight hours after operation. The skin closure is made preferably by interrupted or continuous over and over zygote sutures.

In cases in which the foot has been infected or gangrenous or some evidence of cellulitis has existed sulfanilamide crystals

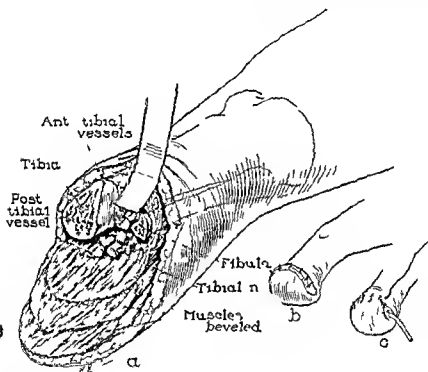


Fig 6 - Stump ready for closure b closed without drain c closed with drain

in a thin coat are applied to the wound before it is closed. Infection if present must have been mild or the amputation should not have been attempted below the knee.

A dressing of dry gauze and cotton pads is then applied and wrapped in place with a roll of 8 inch (20 cm) gauze. The dressing should be firm but not tight. A padded posterior stove pipe splint sufficiently long to extend to the upper part of the thigh and bent to protect the end of the stump is held securely in place with wide strips of adhesive tape.

Oxygen is given routinely with a B L B mask for twenty minutes out of every hour for the first two or three days following operation. A prophylactic dose of polyvalent gas and tetanus antitoxin is given immediately after the operation.

The wound is inspected and dressed at the end of one week and again at the end of ten days to two weeks after amputation. If the wound seems securely healed at the time of the latter dressing the stitches are removed and the patient is allowed to be up and about.

HEALING AND MORTALITY

Healing occurred after sixty five amputations without any complications (Figs 263 and 264). At times healing is delayed but when it is complete the stump is suitable for prosthetic ap



Fig. 63—Amputation below knee two weeks following operation

pliances (Tables 3 and 4). When an ischemic slough takes place it should be allowed to progress until a level for reamputation can be determined. In some instances good bleeding granulation tissue in the wound tends to form early. In such cases all the dead tissue is allowed to slough. Usually it is found

that the skin flaps remain viable. In these cases with slight trimming and removal of a short portion of the tibia a loose closure can be made which will result in successful healing below the knee. In other cases the sloughing of the wound associated with necrosis of skin is deep and secondary amputation below the knee cannot be performed. Early reamputation is then done through the lower or midportion of the thigh.

Occasionally a stump becomes frankly infected. When this occurs immediate action is necessary. Drainage of any sealed



Fig. 264.—Amputation below knee three weeks following operation. Complete healing.

pus is established even at the expense of the suture line and moist warm dressings are applied. The causative organism is sought and a suitable sulfonamide compound is administered by mouth. If the clinical course or findings on palpation of the stump arouse any suspicion of gas gangrene the wound is opened wide and therapeutic polyvalent gas gangrene antitoxin is administered together with treatment with roentgen rays. In nine stumps after 110 primary amputations below the knee *Clostridium welchii* was found on culture. Five of these occurred in cases of thrombo angitis obliterans, two in cases of

arteriosclerosis and two in diabetes. In all therapeutic gas gangrene antitoxins and treatment with roentgen rays were employed immediately. In five of the nine instances healing and recovery followed reamputation through the thigh and in two cases reamputation below the knee. Two patients died, one did not have reamputation and one after reamputation through the thigh.

Gas gangrene was suspected in three more cases either because of the clinical courses or because of palpable gas in the stump, but culture did not reveal *Clostridium welchii*. These patients

TABLE 3

PATHOLOGIC CHANGE AND SUBSEQUENT COURSE FOLLOWING 110 PRIMARY AMPUTATIONS OF LEG BELOW THE KNEE IN 103 CASES

C d t	P t t	P m y Am t t B l w K			
		H l g Without C m p l t n s	C m p l t d H l f Limb		
			S b q t S g l P o c e d	R m p t t	
				B l w K	A b o v K
Th b o- g t b l t r a	57	34	8	7	13
A t o s c l o s i s b l t r a s w t h d b e t e s	28	20	6		3†
A t o s c l o s i s b t w t h t d b e t e s	16	10	2	1	4
A t r t l o c l d t m b o l m t h m b o s s	2	1	1‡		
T t l	103	65	17	8	20

† O p a t t d d f g a s g 5 d y f t p t
 ‡ P t t d d f p m R a g f t 6 d a y f t p t
 21 d y f t p r a t

were treated for gas gangrene and all underwent reamputation above the knee which was followed by healing and recovery. An additional death resulting from pneumonia and cardiac insufficiency on the twenty first day following operation brought the number of deaths in this series of 110 amputations in 103 cases to three. This surprisingly low incidence of mortality can be accounted for to some extent by the careful selection of cases for amputation below the knee. The aid which the surgeon receives in the preoperative and postoperative care of these patients from the vascular and diabetic medical services must be acknowledged and much appreciated.

Tables 3 and 4 are self explanatory. In all cases healing of the stump was secured ultimately and maintained while the patients were under observation. In one case of thrombo angitis obliterans amputation below the knee was followed by complication with reamputation below the knee healing did not occur so reamputation was performed above the knee. Both surgical procedures are listed in Tables 3 and 4 in order to keep the number of reamputations correct.

TABLE 4

ALL PATIENTS UNDER OBSERVATION

Type of Amputation	Healed	Amputation	
		Primary	Secondary
Healed	60	65	
Complicated healing	1	17	
Complications Reamputation below knee	7	8	8
Complicated Reamputation above knee	19	20	20
Total	103	110	28

Of the 103 patients who had healed amputations below the knee, 65 had single amputations below the knee, 17 had complicated amputations below the knee, 8 had reamputations below the knee, and 19 had reamputations above the knee.

PROSTHESES

After One Amputation—A determined attempt was made to obtain follow up information on patients who had single amputations below the knee. At the time sixty eight of the patients left the Clinic it was thought that they would be able to wear a prosthesis. Eleven of these patients were not followed. Two patients died within a year from other causes but they never had obtained an artificial limb and one was in the process of securing a limb at the time this paper was written. Four patients who died one to two years after leaving the Clinic never wore an artificial limb. One patient now living has never worn a prosthesis. Three patients stated they wore their prostheses about 50 per cent of the time. Two patients were hindered by some irritation of the amputation stump and one by an occa-

sional ulcer Forty six patients stated they were able to wear a prosthesis all of the time without any significant discomfort This would mean that 80 per cent of the patients on whom follow up information was obtained who had had the opportunity to secure an artificial limb were wearing one with satisfaction

Eleven patients stated that they had mild symptoms of chafing callouses or blisters but that they wore their limbs all of the time Six patients stated they had had previous trouble of a more serious nature in the form of an ulcer or some drainage removal of a piece of sequestrum had been necessary in three of these cases The longest period any of these major symptoms had persisted was five years However at the time of reply all these patients were wearing artificial limbs full time In this latter group all complications occurred in cases of thromboangitis obliterans One patient complained of pain over the fibular stump One patient complained only of mild phantom pain It was necessary to remove a spur in one case because of irritation of the stump

After Bilateral Amputations—There are a confusing number of combinations which bilateral amputations of the legs may assume In occlusive vascular diseases these combinations frequently change as vessels in the extremity on which amputation has been performed as well as in the other extremity become occluded In this follow up study all amputations to which the patient had been subjected at the time the patient replied to our inquiry whether the amputation was done at the Clinic or elsewhere are included Five patients had had both legs amputated one through the tibia the other through the thigh Two of these patients did not wear artificial limbs one wore artificial limbs 50 per cent of the time and two patients wore them all the time

Of nine patients who had had bilateral amputations of the legs below the knee and were followed up one wore prostheses only 50 per cent of the time and walked with the aid of crutches and eight wore them with comfort all of the time

During a period similar to that covered by this paper 203 patients had amputations through the thigh at the Clinic While follow up data is not as satisfactory because of the advanced age of patients in this group and the frequent early deaths the figures gleaned are significant In fifty nine cases of single ampu

tations through the thigh follow up data was obtained. Only twenty eight of these patients wore a prosthesis all the time. Ten wore a limb less than 50 per cent of the time and two of these used crutches as an aid. Twenty one patients did not use an artificial limb.

Follow up data was secured on seven patients who had had amputations through both thighs. Two patients were able to use bilateral prostheses all the time. One patient was in the process of obtaining an additional limb and four were unable to walk. Of the cases of amputation through the thigh in which follow up data was obtained a prosthesis was worn with satisfaction on thirty three limbs and on thirty nine limbs the wearing of a prosthesis was not attended with satisfaction. Thus prostheses could be used satisfactorily on less than 50 per cent of the limbs after amputation through the thigh.

Type of Prosthesis—The make of prosthesis apparently made no difference as many different kinds were used. When the stump was satisfactorily fitted the patient was able to use his limb all the time. Several patients stated they had tried two or three limbs before finding one which could be worn.

SUMMARY AND CONCLUSIONS

Amputations below the knee in occlusive vascular disease are not as hazardous as commonly believed if cases are selected with good surgical judgment. One hundred and ten amputations below the knee have been performed on 103 patients at the Clinic in the past eleven and a half years with only three deaths. Reamputation was necessary above the knee in twenty instances. The percentage of patients who wore prostheses for amputations below the knee is sufficiently greater than those who wear prostheses for thigh amputations so that more frequent attempts at the former procedure should be urged.

OLD AND NEW FRACTURES AND FRACTURE DISLOCATIONS OF THE ASTRAGALUS

PAUL R. LIPSCOMB and RALPH K. GHORMLEY

Fractures of the astragalus are comparatively uncommon. During the present war, however, these injuries will probably be seen much more frequently than formerly owing to the terrific mechanical forces that are in effect. The fracture usually is produced by striking on the foot after a fall from a height. The same mechanical effect may be obtained of course by an explosion beneath the deck of a ship, the deck thereby being forced upward against the sole of the foot with great force. Under these circumstances trauma is severe and fractures of the os calcis and distal end of the tibia and fibula may be associated.

With the exception of the chip fractures of the astragalus which usually are caused by a sudden twist of the foot on the ankle, all fractures of the astragalus are serious. The resulting deformity and loss of function are likely to be severe and great skill is required by the attending physician in the treatment of this injury. The degree of skill necessary is indicated by the fact that treatment has never been standardized and there is still confusion in the minds of authorities concerning the best methods of treatment. Only through analysis of the late results of treatment can the best forms of therapy be determined. It is our purpose in this presentation to analyze the results in the 114 cases of fractures and fracture dislocations of the astragalus encountered at the Mayo Clinic to January 1, 1940.

Fractures of the astragalus are analogous to fractures of the neck of the femur because the astragalus receives its blood supply much as the femur does. The astragalus receives the majority of its blood from a branch of the dorsalis pedis artery which enters the lateral aspect of the neck. The remaining blood is supplied by small branches entering at the ligamentous and capsular attachments. Thus in a fracture of the neck of the astragalus proximal to the nutrient artery the blood supply

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CHIP FRACTURES

Practically all of the chip fractures in the group of sixteen patients were caused by missteps with resulting indirect falls and thus triangular ligament tears with avulsion of a chip from the astragalus. As would be expected, then, the great majority of this group of patients (eleven) were women only five were men. The average age of the patients was forty two years. Treatment consisted of application of a cast from the toes to the knee in seven cases and taping in seven. Rest or no active treatment was the choice of therapy in two cases. Resulting function of the ankle was excellent in eleven cases good in three fair in one. In one follow up data were not adequate. The results among patients treated by application of casts and those treated by taping were not appreciably different except that the fair result occurred in a case in which Sudel's atrophy (osteoporosis) developed after application of a cast and several months of disability resulted.

NEW FRACTURES OR FRACTURE DISLOCATIONS

Twenty two new fractures or fracture dislocations occurred in twenty patients all of whom were seen during the period of possible primary reduction. None were therefore more than two and a half weeks old. The average age of this group of patients was thirty five years thirteen were males while only seven were females.

Thirteen of these patients gave a history of a fall from a height three gave a history of a crushing injury and three of a combination of a crushing injury and a fall. The method of injury was not elicited from one patient.

Eleven fractures were simple (only one line) five were comminuted fractures three were simple dislocations, one was a comminuted fracture with dislocation one a compound comminuted fracture and one a compound comminuted fracture with dislocation.

Seven simple fractures were through the neck of the astragalus and one was through the body. The neck and body were both involved in eight fractures. Three of the cases presented simple dislocations at the tibio astragalar joint. The location of the remaining three was not definitely recorded.

Treatment of one minor fracture of the posterior process which was really little more than a chip fracture consisted of

taping. Closed reduction with application of a cast was performed for ten fractures. Open reduction was performed for eight fractures. Internal fixation with beef bone screws was used for two of these eight fractures. The astragalus was completely excised for two fractures and partially excised for one.

TABLE 1

RESULTS OF TREATMENT OF TWENTY TWO FRACTURES AND FRACTURE DISLOCATIONS OF THE ASTRAGALUS

Result	Type	Closed Reduction	Open Reduction	Astraglectomy		Total
				Partial	Complete	
Excellent	1	4	2			7
Good		2	3	1		6
Fair		1	2		2	5
Inadequate follow up		3	1			4

None of the results were considered poor.

The results of treatment are shown in Table 1.

Four cases are reported to illustrate the treatment and results in this group of fractures.

Case 1—A youth nineteen years of age on July 23, 1935, jumped from a wagon when a team of horses pulling the wagon ran away. He thereby sustained an injury to the left foot. A fracture of the astragalus was diagnosed and this was manipulated by the home physician but reduction was not accomplished. Three days later the patient was sent to the Mayo Clinic.

Roentgenograms (Fig. 265) on admission revealed a fracture through the neck of the astragalus with upward displacement of the neck. The next day open reduction was performed and the fragments were held in anatomic reduction by a beef bone screw. A cast which was applied was changed at the end of three weeks at which time the wound was healed. On October 3, 1935, a little more than two months after operation, union was good clinically and roentgenographically (Fig. 266). The patient was allowed at this point to begin graduated weight bearing and was instructed by the physical therapy department in foot exercises. One month later the patient reported that he was walking without a limp. He did not reply to a follow-up letter which was sent one year later.



Fig 265 (Case I) —Fracture of the astragalus with upward displacement of the neck



Fig 266 (Case I) —Two months after open reduction and fixation with a beef bone screw Union is complete

Case II —Another patient a woman aged forty four years had a fracture similar to that in Case I This was reduced and held with a beef bone screw The patient made an uneventful recovery and

one year after operation walked normally although slight osteoporosis and aseptic necrosis were present.

Case III—A man forty six years of age on September 20 1940 fell a distance of six feet and landed on the left heel. Roentgenograms (Fig. 267 *a* and *b*) revealed a fracture of the left astragalus with the proximal fragment displaced anteriorly and the distal fragment displaced posteriorly and medially. There was also a fracture of the internal malleolus. Traction with a Kirschner wire through the os calcis was instituted for five days at the end of which time



Fig. 267 (Case III)—Fractures of the astragalus and internal malleolus. *a* anteroposterior and *b* lateral views.

open reduction was performed and fixation secured with one vitalium screw in the astragalus and two through the internal malleolar fracture. On November 15 1940 it was noted that the fracture had united but that the body of the astragalus was more dense than the neck (Fig. 268). Weight bearing had been started but was stopped soon. Six months afterward it was believed revascularization was occurring. Gradual weight bearing was begun again in January 1942. The patient was walking without a limp in April and dancing in August when roentgenograms revealed definite increase in revascularization (Fig. 269).



Fig 268 (Case III) —Seven weeks after open reduction and fixation with vitallium screws Aseptic necrosis of the body of the astragalus is present although the fracture has united



Fig 269 (Case III) —Twenty three months after operation Increase in vascularization of the body of the astragalus is noted



Fig. 0 (Case IV) — Location of the astragalus *a* anteroposterior and *b* lateral view



Fig. 1 (Case IV) — *a* and *b* After reduction

Case IV—A man aged fifty years sustained simple dislocation of the astragalus when he fell several feet landing on the right foot (Fig 270 *a* and *b*) Closed reduction was accomplished (Fig 271 *a* and *b*) and after immobilization in a cast the patient made an excellent recovery

OLD FRACTURES AND FRACTURE DISLOCATIONS

The seventy eight patients in this group were seen at the Clinic from several weeks to many years after the original injury These patients had seventy nine fractures The average age of the patients in this group was thirty six years, the youngest was seven years of age the oldest, seventy eight years Sixty seven were males and only eleven were females The average lapse in time from the date of the fracture until the patients were seen at the Clinic was thirty four months Of the thirty eight patients of this group who underwent operation at the Clinic because of the old fracture the average lapse in time from the accident to observation at the Clinic was ten months The average lapse in time for the remaining patients who were not operated on was fifty seven months

Thirty two patients gave a history of a fall from a height twenty gave a history of a crushing injury and four of a crushing injury with a fall Nine injuries to the astragalus were caused by indirect falls that is a twist of the ankle with a fall to the ground The type of injury was not elicited from thirteen patients

Twenty seven of the seventy eight patients had simple (only one line) fractures eighteen had comminuted fractures, fourteen simple dislocations eight dislocation with a simple fracture five dislocation with comminuted fracture and six did not know the original type of fracture Ten of the seventy nine fractures or fracture dislocations were compound

The original fractures involved the neck of the astragalus in eighteen cases and the body in nine cases while in two the body and neck were both involved When the patients were seen at the Clinic it was impossible to state the exact location of the original injury in forty nine cases

Forty patients who had old fractures or fracture dislocations did not receive operative treatment after they were seen at the Mayo Clinic The original treatment instituted by the physicians in the home locality for these forty one fractures or fracture

dislocations was as follows: rest in bed only for one, fracture taping alone for three, closed reduction for twenty, open reduction for eight, excision of part of the astragalus for one, no treatment for four, and for four the former method of treatment was not recorded.

The results of treatment elsewhere in this group were as follows: excellent for two, fractures good for ten, fair for twenty, and poor for five. We were unable to evaluate the results of treatment of four fractures.

The remaining thirty-eight patients who had thirty-eight old fractures were treated by surgical procedures at the Clinic. Of this group, three had undergone operation elsewhere. First surgical measures employed at the Clinic in this group of cases were as follows: manipulation and application of cast in attempt to improve position of the foot in three cases, open reduction in three, subastragalar or triple arthrodesis in five, tibio-astragalar arthrodesis in two, osteotomy of the lower part of the tibia and fibula in three, excision of the entire astragalus in seven, excision of part of the astragalus in fourteen, and excision of the entire astragalus followed later by amputation in one case.

The results of treatment at the Clinic in this group of thirty-eight cases, with particular reference to the type of treatment, are given in Table 2.

TABLE 2

RESULTS OF TREATMENT FOR THIRTY EIGHT OLD FRACTURES AND FRACTURE DISLOCATIONS OF THE ASTRAGALUS

Results	Open Reduction Osteotomy Arthrodesis	Manipulation	Partial Complete Astraglectomy	Total
Excellent	2	1	0	3
Good	4		8	12
Fair	3	1	3	7
Poor	1	1	3	5
Unable to evaluate	3		8	11

The cases of old fracture which we are reporting illustrate the methods and results of treatment in the group of old fractures and fracture dislocations.

Case V—A girl aged eleven years sustained a fracture of the astragalus one month before she was seen at the Clinic. Roentgenograms revealed malposition at the site of fracture (Fig. 272). Open reduction was planned but when the site of fracture was inspected



Fi (Case V) —One month after fracture of the astragalus with malposition union was proved at operation

firm union was present. The wound then was closed and the foot manipulated into good position. When last heard from this girl was walking without pain but it is only natural to assume that traumatic arthritis will develop in time.

Case VI—A youth sixteen years of age sustained a fracture dislocation of the neck of the right astragalus three months before he was seen at the Clinic. On exploration of the wound it was impossible to reduce the fracture; therefore one of the fragments was removed and subastragalar arthrodesis was performed at the same time as it was evident that severe traumatic arthritis would develop otherwise (Fig. 273). This patient did not reply to a follow-up letter which was sent him so that we do not know the final result. However in picked cases this surgical procedure should be borne in mind.



Fig. 273 (Case VI) —Partial astraglectomy with subtragalar arthrodesis. Aseptic necrosis of body of astragalus is present.

Case VII —The patient was seen first at the Clinic on November 23, 1931. Nine months previously fracture of the astragalus had occurred. The fracture was not compound according to the history. After immobilization for one month the attempt at closed reduction made elsewhere had been unsuccessful. In June, 1931, partial astraglectomy had been done elsewhere, after which osteomyelitis and infection developed. Roentgenograms at the time of admission to the Clinic made us raise the question of tuberculosis or Charcot's joint (Fig. 274), especially since the serologic reactions were positive for syphilis. Because of the marked swelling, increased local heat and loss of motion, the patient was given physical therapy in an attempt to correct deformity of the foot which had developed. As he did not respond to this, complete astraglectomy was performed December 19, 1931, at which time care was taken to displace the foot posteriorly. Three months later the wound had completely healed and good stability was present and the patient walked with the foot flat on the ground. On March 15, 1933, the patient was still having considerable pain and was not satisfied with the result. When last heard from in October, 1940, he was having pressure sores on the foot, considerable swelling of the foot and on overactivity much pain.



Fig 274 (Case VII) — Nine months after fracture of the astragalus osteomyelitis and sequestra may be noted

Case VIII — The patient a woman aged forty three years was seen because of compound fracture of the left ankle sustained in an automobile accident three and a half months previously. Drainage had occurred from three different regions since the accident.

On examination at the Clinic the lower part of the left leg was swollen and edematous and numerous sinuses were present. There was increased motion in the foot with some crepitus on motion. Anteroposterior and lateral roentgenograms (Fig 275 *a* and *b*) showed an old trimalleolar fracture of the left ankle joint and fracture of the left talus bone with marked osteoporosis of the bones of the ankle joint. The patient was hospitalized and two good sized sequestra were removed from the medial side and one large sequestrum from the outer side of the astragalus. There was definite improvement in the strength of the foot and at the end of one and a half years ankylosis was almost complete (Fig 276 *a* and *b*). In reply to a letter two years later the patient stated that she could walk about the house but had difficulty outside. She still had pain much of the time and swelling on walking. She was still having a little drainage when last heard from.

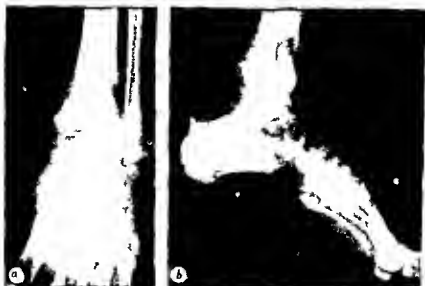


Fig. 275 (Case VIII) — Fifteen weeks after compound fracture of the tibia and fibula. The tibia and fibula are in position of the tibia and fibula after repair of the lateral ends.



Fig. 276 (Case VIII) — One and a half years after sequestrectomy and union of the tibia and fibula. The tibia and fibula are in position of the tibia and fibula after repair of the lateral ends.

COMMENT

In the major fractures of the astragalus disability may result not only from the fracture per se but (1) from aseptic necrosis (2) from traumatic arthritis and (3) in compound fractures and in cases of open operation from infection of the astragalus which is likely to lead to severe damage with sequestration of part or all of the bone. This complication may necessitate removal of the astragalus.

It may be possible at times to reduce severe fractures of the astragalus by closed manipulative procedures. In such instances the surgeon should be absolutely certain that the reduction is accurate and complete. In such cases and in cases of fracture without displacement fixation by means of a well fitted plaster of paris cast for eight or ten weeks should suffice. After that weight bearing may be commenced. In all cases roentgenograms should be inspected carefully for evidence of aseptic necrosis and if it is present full weight bearing should be delayed until the bone has resumed a nearly normal appearance even if it is necessary to curtail activity and not permit normal weight bearing for many months.

In cases of fracture or fracture dislocation with severe displacement in which manipulative treatment fails to produce accurate reduction open reduction is indicated. As a rule a lateral incision along the ankle about the level of the subastragalar joint is carried forward and curved slightly toward the base of the heel of the astragalus. The peroneal tendons should be protected if possible but if necessary in order to gain a better exposure of the joint they may be divided and resutured at the end of the operation. The foot may be inverted to an extreme position and the fragments replaced in position. Fixation of the fragments should be by means of stainless steel screws. It should be pointed out and emphasized that in cases of comminuted fractures in which more than two or three fragments exist little can be gained by open reduction as the comminution makes adequate fixation by any internal means impossible.

After open reduction and fixation the same program should be followed as indicated after closed reduction. The patient again should be watched for evidence of aseptic necrosis as well as for evidence of traumatic arthritis of the tibio astragalar joint as well as the subastragalar joint.

In cases of compound fracture debridement of the wound



Fig. 74 (Case VIII) — Fourteen weeks after compound fracture of the astragalus and distal portions of the tibia and fibula. The joint is stabilized after placement of pins. Lateral views.



Fig. 276 (Case VIII) — One and a half years after surgical myodesis and immobilization in casts ankylosis is almost complete. Medial and lateral views.

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COMMENTS AND QUERIES ON PRIMARY BENIGN AND MALIGNANT TUMORS OF BONE

HENRY W MEYERDING

The general practitioner rarely has to assume the responsibility for the diagnosis and treatment of bone tumors. When such problems do confront him he usually seeks aid from the literature or consults a more experienced colleague. The data and material accumulated by the Bone Sarcoma Registry of the American College of Surgeons and the larger medical centers are the most comprehensive and reliable sources of information regarding malignant tumors of bone. Conclusions of real value can be drawn only from records which provide facts concerning the history and clinical and laboratory findings together with the surgical, microscopic and postoperative data and contain all the essential information.

Although information of great value may be gained from the history, clinical, laboratory and roentgenologic findings in cases of tumor of bone, experience has shown that the correct diagnosis and gravity of the prognosis may not be recognized until metastasis has appeared. In some instances the surgeon and pathologist have found themselves in error in spite of their efforts and not until necropsy has the true nature of the lesion been discovered. Close cooperation between the clinician, the roentgenologist, the pathologist and the surgeon is essential in arriving at an accurate diagnosis. The surgeon in charge of the patient should have an open mind as to the value of nonsurgical methods of treatment. The roentgenologist likewise must realize his limitations in interpretation of the roentgenologic findings and treatment. When the surgeon and the roentgentherapist cooperate to the fullest extent after early and accurate diagnosis, in my opinion the prognosis in the treatment of tumors of bone should improve.

Present knowledge concerning bone tumors can be best covered by answering some of the questions which often arise when ever bone tumors are discussed. These questions and answers follow.

Now handle I under the auspices of the American Academy of Orthopaedic Surgeons

CLASSIFICATION DIAGNOSIS AND PROGNOSIS

Is there a practical classification of lesions simulating tumors and of benign and malignant tumors of bone?—The classification which I have worked out and use at present is given in the tabulation

TABULATION

LESIONS SIMULATING NEOPLASMS AND TRUE NEOPLASMS OF BONE

I Lesions Simulating Neoplasms of Bone

A Inflammatory lesions

1 Traumatic lesions (callus ossifying hematoma)

2 Infections (syphilis tuberculosis osteomyelitis nonsuppurative osteomyelitis of Garre Brodie's abscess myositis ossificans osteoperiostitis)

B Osteitis fibrosa cystica

C Metabolic lesions

1 Hand Schuller Christian disease Caucher's disease Niemann Pick disease hyperparathyroidism

D Nutritional lesions

1 Rickets scurvy

II Neoplasms in Bone

A Benign osteogenic tumors

1 Osteoma (exostosis)

2 Osteochondroma

3 Chondroma

B Fibroblastic tumors

1 Benign fibroma

2 Malignant periosteal and cortical tumor

C Giant cell tumors

1 Benign giant cell tumor

2 Malignant giant cell sarcoma

D Vascular neoplasms

1 Benign hemangioma (cavernous or plexiform) lymphangioma

2 Malignant hemangioendothelioma (diffuse endothelioma or Ewing's tumor or Ewing's sarcoma) lymphangioendothelioma

E Malignant osteogenic sarcoma (including chondrosarcoma)

F Multiple myeloma

C Metastatic tumors

H Miscellaneous group

1 Undifferentiated malignant neoplasms

Lymphosarcoma liposarcoma erythroblastoma chondrosarcoma

What are some of the factors which influence the early diagnosis of tumors of bone?—Much depends on the ability of the general practitioner for he is first consulted by the patient and has the opportunity of treating him. During the early stages of the disease the symptoms and clinical findings are so vague that they baffle the expert diagnostician. The most valuable aid at this early period is the roentgenogram. Roentgenograms of regions in which there is persistent localized pain should be made immediately. I have repeatedly seen patients who have been treated with heat massage and local applications for months because they were thought to have a sprain fracture rheumatism or arthritis whereas a roentgenogram would have readily revealed the presence of a tumor of bone. Patients and physicians must learn the value of the roentgenogram and when ever localized pain persists they must consider the possibility of a tumor of bone (Case I).

Will early diagnosis alter the treatment and prognosis?—There is decided advantage in treating a patient who has a tumor of bone that has not attained great size and this one factor may be the determining element in the result obtained from treatment. Most benign tumors of bone are cured by excision and only present difficulty when they attain such a size that surgical removal is hazardous or impossible. Thus the benign osteogenic tumors of bone (exostosis osteoma chondroma or fibroma) commonly termed osteochondroma when discovered before they have attained great size can be eradicated by surgical removal the same fact is true of the benign giant cell tumor of bone.

The malignant osteogenic sarcoma the malignant giant cell sarcoma and the periosteal fibrosarcoma unless discovered early all produce metastasis and death. Five year cures however have occurred in many cases of this type in which treatment has been carried out early and in some cases in which the lesion has been discovered before extensive involvement had taken place the extremity and function have been preserved. I have encountered some cases of this type too in which pulmonary metastasis was found on examination even though the primary tumor had not been discovered previously. These patients however had had prolonged localized pain at the site of the primary tumor. In such instances treatment is of no avail and the prognosis is grave.

Multiple myelomas have not responded to treatment and those which appear to be localized growths frequently prove to be multiple. This is one group of bone tumors which has failed to respond in spite of early diagnosis and treatment; the average life expectancy after onset of symptoms is about four teen months.

ROENTGENOGRAPHIC EXAMINATION

What can be learned from the roentgenogram of a tumor of bone?—The location of the lesion, its size in relationship to the surrounding tissues and something regarding its structure usually can be determined from the roentgenogram. When the tumor extends outside the cortical substances of the bone it is found to invade or penetrate the soft tissue. The location of a tumor of bone is of value too in the diagnosis. In cases of congenital exostosis (benign osteochondroma) the tumor frequently arises at the end of the diaphyses and during growth has a tendency to grow in a direction *away* from rather than toward a joint. Benign giant cell tumors have been referred to as the epiphyseal giant cell tumors since they frequently occur at the epiphyses. The size of the tumor and its proximity to or in vasion of important structures may be the deciding factor in the type of treatment employed. A small well circumscribed tumor may grow close to a joint and excision of this tumor may result in cure, whereas a larger lesion may have attained such size that any possibility of surgical removal is precluded and thus amputation is necessary. For example, a chondroma in its earlier stages may be excised and cure effected by this means, whereas in its later stages of growth I have seen the most radical type of surgical treatment fail because the lesion had extended into inaccessible regions where it had continued to form new masses of tumor tissue.

I wish to emphasize particularly that the roentgenogram furnishes information concerning the destruction or formation of bone, the definiteness or indefiniteness of the outline and evidence of invasion or penetration of soft tissue, of the reaction of the periosteum and of the danger of pathologic fracture as a result of weakness of the bone structure from extension of the growth. Correlation of the information obtained from the history and from roentgenographic and clinical examinations results in accurate diagnosis of many of the lesions of bone.

but the term **giant cell sarcoma** has been used loosely and frequently it is used to designate a tumor of the benign type. I have proposed in previous publications that the terms **benign giant cell tumor** and **malignant giant cell sarcoma** are fool proof. In Case II and in previous articles I have reported cases of malignant giant cell sarcoma in which the lesion was located in the epiphysis.

Can the benign and malignant types of giant cell tumors of bone be distinguished clinically?—No. I believe that differentiation must be made on microscopic study of tissue obtained from the tumor. Malignant giant cell sarcoma is rare and often unsuspected and the patient may be treated for a benign lesion by operation or irradiation or a combination of both methods and the condition may be unrecognized until metastasis develops. A thorough microscopic study should be made of the tissue obtained at operation in every case of giant cell tumor of bone.

What is the usual method of treatment in a case of benign giant cell tumor of bone?—Surgical removal of the tumor, cauterization and immediate closure of the wound in cases in which the tumor has not attained great size give the most rapid cure. In some cases surgical removal is not advisable and irradiation is the treatment of choice. Excellent results have been obtained following both methods of treatment. In some cases radical excision of the tumor and bone grafting have prevented deformity and saved a useful extremity for the patient.

How are patients who have malignant giant cell sarcoma treated?—In these cases treatment must consist of radical removal of the tumor especially when the patient comes after the tumor has attained some size. This type of lesion is so rare that reliable statistics concerning the results of treatment are not available. I consider that treatment should consist of radical excision in those cases in which the patient is seen early and amputation in those in which the tumor has attained large size and involved joints. In cases in which it is impossible to remove the tumor irradiation should be employed.

Should biopsy be performed routinely in cases of Ewing's sarcoma (Ewing's tumor or diffuse endothelioma) or hemangioendothelioma or can the diagnosis be made by some other means?—I believe that the irradiation of this type of tumor usually gives such a characteristic response that it is a diag-

nostic procedure. Since I have seen cases in which roentgen operation and microscopic examination of tissue have failed to disclose the true nature of the lesion I wish to caution all physicians against believing in the infallibility of a diagnosis in this type of case. One of the most common errors is to mistake this lesion for osteomyelitis. If there is any doubt concerning the diagnosis a course of roentgen treatment by a competent roentgentherapist should produce a rapid melting of tumor tissue if Ewing's sarcoma is present and a comparatively normal appearance of the involved bone is often the result.

EWING'S SARCOMA (TUMOR)

Is irradiation the treatment of choice for Ewing's sarcoma?—The trend has been toward this method of treatment and from my experience I would try irradiation if I were to have such a tumor. Unfortunately while these tumors may entirely disappear after such treatment they tend to recur with fatal termination.

What have been the five year results following treatment of patients with Ewing's sarcoma?—Of 100 patients treated at the Clinic we were able to trace ninety nine of whom twenty one (21.2 per cent) were living five or more years after treatment.

OSTEOGENIC TUMORS

What is meant by the term osteogenic? Does it mean bone producing?—The use of the term osteogenic tumor has led to confusion. It does not mean in the sense in which we employ it in this country a tumor which produces bone for it may or may not produce bone in the majority of cases of the osteogenic group it does produce bone. As osteogenic tumors include the benign osteoma (exostosis) osteochondroma and chondroma as well as a high percentage of sarcomas the osteogenic tumor constitutes the largest percentage of tumors of bone.

The term osteogenic as I understand it means derived from bone originates in bone derived from cells which have the ability to form bone and derived from ancestors of cells which when fully differentiated are known as osteoblasts. Thus cells which are osteogenic may appear at various stages of differentiation may never produce bone or may form an osteogenic sarcoma of the osteolytic type or dense bone producing what is termed a sclerosing osteogenic sarcoma.

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Is Bence Jones proteinuria diagnostic of multiple myeloma?—No. It occurs in about 60 per cent of the cases and has been found among patients who have other types of lesions.

Do roentgenograms permit a positive diagnosis of multiple myeloma?—When metastasis as a result of carcinoma has been excluded the characteristic punched out round and oval areas commonly seen in the skull ribs sternum spinal column and femurs as well as in other long bones may be diagnostic.

Is there any procedure besides the test for Bence Jones proteinuria and roentgenographic examination which will result in a diagnosis of multiple myeloma?—I believe that the finding of plasma cells on sternal aspiration or biopsy is the answer to this question. Renal damage albuminuria backache reversed albumin globulin ratio autohemagglutination Bence-Jones proteinuria anemia weakness and loss of weight may be present.

FIBROSARCOMA

Are fibrosarcomas more amenable to treatment than osteogenic sarcomas?—Apparently they are. Of thirty six patients who had fibrosarcomas treated at the Clinic and were traced 30.5 per cent lived five years or more whereas only 20.3 per cent of a similar group of patients who had osteogenic sarcoma lived for five years.

Can you give the five year survival rate in any substantial number of cases of primary malignant tumor of bone?—Yes 21.2 per cent.

REPORT OF CASES

Case 1—A girl aged nineteen years was seen December 1, 1930. She gave a history of pain swelling local heat and limitation of motion of the left knee of five months' duration. During the five months time she had had several remissions of symptoms but they had increased in severity. Diathermy and infra red treatments had been used and roentgenograms were taken just prior to coming to the Clinic.

Examination revealed a healthy appearing young girl with swelling of the left thigh increased local heat tenderness and limitation of motion at the knee joint. The clinical and roentgenographic diagnosis was osteogenic sarcoma of the left femur (Fig. 27 a and b). Examination of the lungs revealed no abnormality the blood count was within normal limits the flocculation test for syphilis was negative. Urinalysis revealed some albumin and pus.

which cleared up in about a week. Biopsy was advised and if the lesion proved to be malignant, amputation.

December 4, 1959 a section of tissue was removed and examined by the pathologist who made a diagnosis of osteochondrosarcoma grade 3 on a grading basis of 1 to 4. Amputation at the juncture of the upper and middle thirds of the left femur was performed.

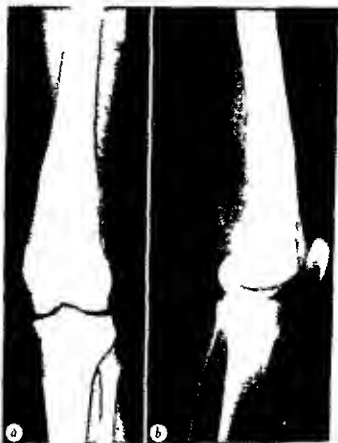


Fig. 7—Osteogenic sarcoma of the lower third of the left femur. a Anteroposterior view. b Lateral view.

immediately. Convalescence was uneventful and the patient was dismissed on the twenty-third postoperative day after she had received a course of roentgen therapy over four fields with converging beams. The technical factors were as follows: 150 kv (constant potential) 16 inches (40.6 cm) distance 6 milliamperes 6 mm aluminum filtration and time eighteen minutes. She was living at the time this paper was written more than three years after treatment was instituted.

Case II—A woman aged thirty seven years was seen at the Clinic September 18 1935 She complained of arthritis since an illness eight months prior to admission and of fever associated with redness swelling soreness local heat and pain in the left knee on walking of four months duration Symptoms had become progressively worse and she had been confined to bed for six weeks

Examination revealed a well developed well nourished woman who had swelling tenderness discoloration local heat and limitation of motion with pain on motion of left knee The roentgen



Fig 278—Malignant giant cell tumor involving the diaphysis and epiphysis

ologist reported giant cell tumor of the lower left femur with soft tissue shadow (Fig 778) The lungs were negative The flocculation test urinalysis and blood count revealed nothing abnormal Biopsy was performed September 23 1935 the pathologist made a diagnosis of malignant foreign body giant cell sarcoma grade 1 Therefore amputation was performed three days later Convalescence was uneventful and the patient was dismissed on the thirtieth postoperative day Before dismissal she received a course of treatment with roentgen rays to three fields with beams of rays con

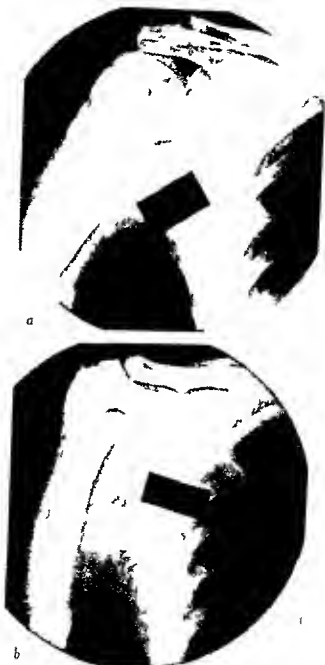


Fig. 79.—Hemangioendothelioma of upper portion of right humerus involving diaphysis and proximal end. Pre-operative radiograph taken June 1, 1931. b. December 14, 1931, eighteen and a half months after operation. Tumor has been excised and a fresh bone graft inserted.

verging the technical factors were 135 kv, 16 inches (40.6 cm) distance 5 milliamperes 6 mm aluminum filtration and time twenty five minutes. She lived three and a half years following treatment.

Case III—A man aged fifty eight years was seen May 31 1921. He gave a history of pain and swelling of the upper part of the right arm of six months duration. A diagnosis of sarcoma had been made and amputation advised. Examination revealed a well nourished man with some atrophy of the deltoid muscle and swelling at the level of the surgical neck of the right humerus. All movements of the shoulder caused pain there was weakness of the arm with some numbness of the thumb. The roentgenologist reported giant cell tumor of the right humerus (Fig. 279 a) and that the lungs were negative. The Wassermann reaction was negative. June 4 1921 the upper third of the right humerus was excised and an homogenous graft inserted and attached with beef bone screw. The pathologist reported that the lesion was a hemangioma. Convalescence was uneventful.

Eighteen and a half months later the patient was examined again. firm union was present (Fig. 279 b) and recovery seemed complete except for atrophy of the muscle and limitation of motion. He could shake hands and do clerical work. Three years later I was told that he had died of carcinoma of the stomach and that the roentgenograms revealed what appeared to be a metastatic lesion. Re study of the tissue removed at operation was carried out and a diagnosis of hemangio endothelioma grade I was made.

Case IV—A man aged forty three years was seen March 12 1937 because of a pulsating tumor of the fifth rib posteriorly on the left side that had gradually increased in size and discomfort since he had noticed it three years prior to admission. Roentgen treatment was given at the Clinic but the tumor failed to decrease in size. May 19 1937 operation was performed half of the rib was excised together with the tumor (Fig. 280). The pathologist reported hemangioma. Convalescence was uneventful and the patient was dismissed on the nineteenth postoperative day. He was living and well at the time this report was written or six years later.

Case V—A woman aged fifty four years came to the Clinic August 23 1937 because of pain in the left thigh of ten months duration. Examination revealed an obese woman with pain on forced motion of the left hip. The roentgenologist reported hemorrhagic bone cyst or giant cell tumor of the upper portion of left



Fig. 80—Hemangioma of the left fifth rib



Fig. 81—Fibroma of the intertrochanteric region of the left femur. *a* Before operation. *b* three months after resection and bone graft.

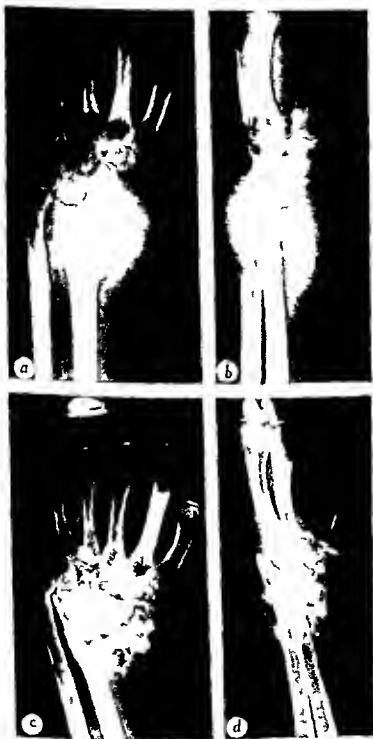


Fig. 8—Giant cell tumor of left radius with complete destruction of lower diaphysis and epiphysis and involvement of the wrist. *a* Anteroposterior view. *b* lateral view. *c* and *d* twenty-eight months after operation and after roentgen treatment marked deformity with shortening of radius and destruction of tumor may be noted.

femur (Fig 281 a) and that the lungs were negative. Operation August 31, 1937, revealed a large firm vascular fibrous tumor 2 1/2 inches (6.3 cm) in diameter within the bone which was shelled out. With it came the posterior portion of the shaft of the femur that was greatly thinned. Bone chips were placed in the cavity and the greater trochanter was brought down and forced into it as well as a cast was applied. The pathologist reported fibroma, probably an exaggerated osteitis fibrosa. Convalescence was uneventful and roentgenograms three months later revealed excellent position and good evidence of union (Fig 281 b).

The patient was living at the time this paper was written, more than five years later, and did not have any evidence of recurrence.



Fig. 83—Huge osteochondroma involving the shaft of the right humerus that was suspected of being a malignant lesion.

Case VI—A woman, aged twenty-two years, was seen May 10, 1937, because of pain and swelling of the left wrist of nine months' duration. She did not give a history of trauma. Operation had been performed and roentgen treatment had been given, but her symptoms had persisted. Examination at the Clinic revealed marked swelling of the lower portion of the left wrist with limitation of motion.

A diagnosis was made of giant cell tumor of the distal end of left radius with impacted fracture shortening and osteoporosis of bones of forearm (Fig 282 *a* and *b*) The lungs were negative Further roentgen treatments were given over a period of three years (Fig 282 *c* and *d*) Five years later the patient reported that she still had soreness weakness and deformity of the wrist but no evidence of recurrence

Roentgen treatment may cure this type of tumor but I believe that surgical treatment offers quicker relief and a better prognosis

Case VII—A man aged forty years came to the Clinic April 7 1936 because of a huge tumor of the right humerus of eighteen years duration During the year just prior to admission the size of the tumor had increased rapidly and it had annoyed him by rubbing against the wall of the thorax A clinical and roentgenographic diagnosis of osteochondroma of the shaft of the right humerus was made (Fig 283) Roentgenograms of the thorax revealed old bilateral pulmonary tuberculosis with left pneumothorax Because of the size of the osteochondroma the patient decided to have disarticulation performed it was done on April 11 1936 The pathologist reported osteomyxochondroma but suggested the possibility of recurrence as a malignant tumor Convalescence was uneventful and the patient was dismissed on the eighteenth postoperative day He reported in January 1943 or six and a half years later that he was well and had had no further difficulty

PRACTICAL APPLICATION OF PLASTIC SURGERY TO THE EXTREMITIES*

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Many plastic procedures can be employed successfully in treatment of lesions of the extremities by the surgeon who is not specifically trained in this field. With the lessening to depletion of men trained in the field of plastic surgery in many localities a review of these plastic procedures seems timely.

SKIN GRAFTS

Skin grafts frequently are indicated in the correction of many conditions both congenital and acquired. The type of procedure chosen should be the one most applicable to the condition to be corrected. In general the grafts most commonly employed are the split skin graft (razor graft), the pedicle graft, the full thickness graft or Wolfe Krause graft and the pinch graft.

Split skin grafts are generally the grafts of choice in regions which are well supplied with subcutaneous tissue. Pedicle grafts usually are indicated in regions which bear weight for use over bony prominences and also for covering defects which expose tendons or bone. Full thickness grafts are frequently indicated in the surgical treatment of conditions about the fingers and hands but thick split skin grafts with only a few exceptions usually can be used instead of full thickness grafts. Pinch grafts are rarely indicated for use on the upper extremity and only infrequently for use on the lower extremity. In this field of surgery they are of use chiefly for patients whose general condition does not permit more extensive grafting.

In this paper I shall consider in detail only the split skin graft and the pedicle graft because they are the two types of graft

The opinions and assertions contained in this paper are the private ones of the author and are not to be construed as official or reflecting the views of the Navy Department or the Navy Service at large.

most frequently applicable to plastic procedures on the extremities

Split skin Grafts

Split skin grafting is facilitated by use of the Paget derma tome for removing the graft (Fig 284) Large grafts accurately gauged as to thickness may be rapidly removed with this derma tome and thus extensive defects can be grafted The successful outcome of the split skin graft is dependent on careful attention to certain principles These principles are as follows

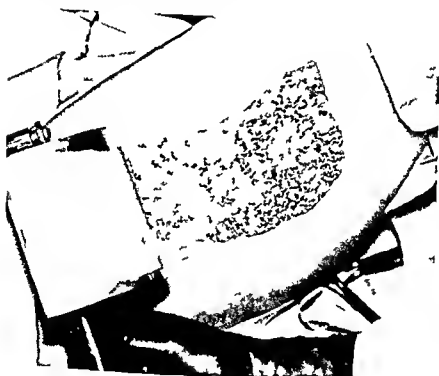


Fig 284—The Paget dermatome

- 1 The split skin graft should be employed only when it is indicated or acceptable for plastic procedure that is for recent traumatic wounds clean surgical wounds and chronic ulcerated wounds with healthy granulation tissue
- 2 Before applying a split skin graft to chronic ulcers or ulcerated wounds the superficial granulation tissue should be shaved to its firm yellow base which has a rich blood supply
- 3 Complete hemostasis should be effected with a minimum of ties Cotton or silk ties should be used while catgut ties should be avoided

4 The graft should be immobilized. After the graft (or grafts) is applied to cover the defect and the graft is so placed that it overlaps the edges of the defect it should be immobilized by running or interrupted sutures of silk or cotton (Fig. 285). The graft is sutured around the margins of the defect and when the defect is large the graft (or grafts) should be sutured throughout the defect.

5 Continuous even pressure should be applied over the graft after operation. Such pressure can be obtained by application of sea sponges, sponge rubber or cotton waste (Fig. 286). Pressure dressings should be continued for a minimum of two weeks.



Fig. 85—Method of immobilization of the split skin graft with sutures.

6 On granulated wounds or potentially infected wounds the graft after its application should be sprayed with sulfanilamide powder. To facilitate adherence of sulfanilamide the graft should be moistened with physiologic solution of sodium chloride. Since all split skin grafts should be perforated before application to allow the escape of serum or collected fluid the perforations will permit local absorption of sulfanilamide.

7 For all infected or potentially infected wounds wet dressings should be employed for a period of five to seven days after operation. The use of wet dressings is facilitated by burying perforated Dakin tubes deep in the dressings. This procedure insures wetting of the deep dressings and lessens the difficulties of protecting bedclothes and so forth. The solutions generally

employed are physiologic solution of sodium chloride 0.8 per cent solution of sulfanilamide or weak Dakin's solution (1:4).

8 The wound should be dressed for the first time from the fourth to the seventh day after operation. The time depends on the wound grafted and the evidence of complications such as odor, drainage or unexplained rise in temperature. At the time of the first dressing visible blisters or regions of infection should



Fig. 86—Method of employing compression dressings

be unroofed. When wet dressings are employed they should be discontinued as early as feasible and grease dressings instituted such as plain vaselin gauze, scarlet red gauze, cod liver oil ointment or a 10 per cent ointment of one of the sulfonamide compounds.

9 Although pressure dressings should be continued usually for a minimum of three weeks, the grafts should be supported

especially when it is on the lower extremity for a period of six to eight weeks

Chronic ulcerated regions usually respond to hot wet dressings with compression. The solutions most suitable for the wet dressings are physiologic solution of sodium chloride and Dakin's solution. Granulations which are firm pink to reddish in color bleed easily on irritation and are relatively painless are usually healthy. Unhealthy granulations are usually grayish painful on irritation and frequently ooze a purulent or seropurulent fluid (Figs 284, 285 and 286)

Pedicle Grafts

Pedicle grafts consist of skin and subcutaneous tissue which are elevated from the underlying tissue except at its pedicle or pedicles. Pedicle grafts as mentioned previously are usually indicated for covering defects on weight bearing surfaces, defects which expose bone or tendon structure and defects over bony prominences which have little overlying subcutaneous tissue.

Pedicle grafts are of three types: (1) the French or sliding graft in which the graft is slid or moved from its original bed with little torsion or twisting of its pedicle; (2) the Indian type of graft which is transplanted by twisting or rotating its pedicle; and (3) the Italian or distant graft which is taken from a surface distant from the site to be grafted. For practical descriptive purposes, pedicle grafts are best described as immediate or delayed, single or double pedicle grafts. Tubed pedicle grafts are rarely used in plastic procedures on extremities.

Immediate single pedicle grafts are employed to cover small defects and the procedure is carried out without preliminary preparation of the graft. As broad a base as possible should be maintained at the time of elevation of the graft. There should be a minimum of twisting or rotation.

Delayed single pedicle grafts are prepared grafts. These grafts are employed to cover large defects and defects for which an immediate pedicle graft is not feasible. They are usually transplanted from a distant site; therefore added length is required to permit the transfer and of necessity preparation is required to insure an adequate blood supply. Two to three weeks are usually required in the preparation of delayed single pedicle grafts and several principles should be observed.

1 The donor site should be so chosen that the patient will have maximal comfort during the period of transference and will not have a visible scar. Scarring is of particular concern to women and whenever possible, scarring below the knee should be avoided.

2 The ratio of length to breadth of the graft should not routinely exceed a ratio of 3:1. In those instances in which this ratio cannot be maintained because a long graft is required a longer period of preparation should be consumed.

3 The graft should be prepared by elevating it between two pedicles and resuturing it in its bed at intervals of seven to ten days until the blood supply is adequately established to nourish the graft on severance of one of its pedicles. For safest preparation three elevations should be used.

4 The defect left by transplanting the graft should be closed by a split skin graft. This grafting is safely done at the time of the third elevation of the pedicle graft or at the time of the final elevation of the graft when one pedicle is cut prior to the transplantation.

5 Adequate fixation of the extremity or extremities at the time the graft is transplanted is necessary to prevent traction, angulation of or undue torsion on the transplanted pedicle graft. On the lower extremities plaster of paris casts are best employed. For fixation of an upper extremity following the initial transplantation and suturing of a graft, bandages and adhesive dressings usually suffice as the grafts are often taken from the abdominal or thoracic wall.

6 Final severance of the pedicle is determined by the amount of established circulation. This may be gauged to some extent by the condition of the recipient region and on the attachment secured at the time of the initial transference. It is generally safe partially or completely to sever the pedicle twenty one days after transplantation.

Double pedicle grafts usually are employed as immediate grafts and function chiefly in covering traumatic defects of the hands and fingers. They are at times indicated in treating recent traumatic wounds of the lower extremity in which case the graft is elevated and shifted to cover the defect. They may be employed in a similar manner to cover defects of a chronic nature.

Double pedicle grafts also have been described as sleeve graft and have been employed in the manner of a glove graft.

If double pedicle grafts are indicated as delayed double pedicle grafts they should be prepared in a manner similar to that described for the preparation of delayed single pedicle grafts

UPPER EXTREMITY AND AXILLA

Plastic procedures on the upper extremity are employed in correction of congenital or acquired deformities or defects

Congenital Deformities of the Hands and Fingers

Plastic procedures for the correction of *syndactylism* (webbed fingers) should be deferred until the patient is four to five years



Fig 287—Bilateral syndactylism of the third and fourth fingers. The plastic web. *a* preoperative appearance *b* postoperative appearance of both hands

of age unless the development of the finger or fingers is retarded
Before attempting any surgical procedure it is well to rule out



Fig. 88—Syndactyly of the third and fourth fingers with the web extending to the distal interphalangeal joints *a* and *b* before operation *c* and *d* postoperative appearance of the hand (defects filled with split skin grafts)

the presence of other congenital anomalies by means of a roentgenologic examination

Flap operations alone should be avoided except in cases in which the web is sufficiently wide to allow easy covering of

the residual defects. In the flap operation one flap is taken from the dorsal surface of the finger with its base toward one digit. Another flap is taken from the palmar surface with its base toward the next digit. The web is then dissected leaving the two

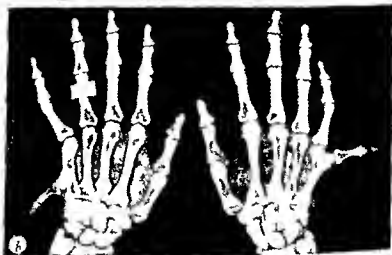


Fig. 89. *a* and *b*. Bilateral accessory fifth finger.

flaps. These flaps are then sutured into position over the raw surfaces (Fig. 287, *a* and *b*).

In the majority of instances the web is not sufficiently large to permit a satisfactory flap operation and it is necessary to graft skin from other sites on the raw surfaces. The amount of webbing as stated previously may be variable and in those

instances in which webbing extends to the tips of the fingers the web may not be mobile and thus it will be necessary to graft the entire medial and lateral aspects of the digits. In such an instance the web is divided in the midline without any plan for flaps with the exception that the web at the base of the fingers should be retained to cover and maintain the interdigital space. Webbing which is present but insufficient to cover the defects after division should be employed to cover as much of the defect as is feasible. Split skin grafts are sutured into position

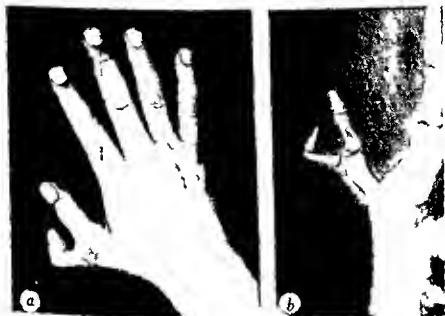


Fig 290—*a* and *b* Accessory thumb

over the remainder as previously described (Fig 288 *a*, *b*, *c* and *d*)

In correction of *polydactylism* the problem is the removal of accessory digits which may vary from an outgrowth of one of the fingers to a completely formed extra digit. The accessory finger may be only skin and subcutaneous tissue. Incisions should be so placed that after amputation of the digit sufficient skin remains for closure of the defect. Split-skin grafts may be indicated in cases of *polydactylism* associated with *syndactylism* of the accessory digit (Fig 289 *a* and *b*)

In well developed *accessory thumbs*, part of the thenar musculature may be attached to the accessory thumb. In such a case the muscle attachment should be saved and sutured to

the remaining phalanx after removal of the accessory digit. If removal of radially placed accessory thumbs leaves a defect in the capsule on the lateral aspect of the metacarpophalangeal joint repair is necessary. The defect may be repaired by dissecting free a flap of nearby fascial tissue and suturing it to cover the defect (Fig. 290 *a* and *b*).

Surgical treatment for *claw hands* (congenital cleft hand) can only be directed toward improvement of function in prehensile motions. In those cases in which operation seems indicated bone fusion or fascial fixation may be done to reproduce the opponens motion of the thumb.

Acquired Defects

Fingers—After avulsion of the tip of a finger the surgeon can cover the defect with an immediate single pedicle graft which is elevated from the thenar or hypothenar eminence. The graft is U shaped and its pedicle in each case is the portion of the graft nearest to the wrist. The defect of the graft bed may be covered with a small split skin graft or the defect may be allowed to heal in by granulation and epithelization. When a graft is used it is sutured into position covering the avulsed tip of the finger. It may be necessary to pass sutures through the nail to secure adequate fixation of the graft. The flexed finger can be satisfactorily immobilized with adhesive and roller bandage dressings. Usually the pedicle if a pedicle graft is used may be severed after from sixteen to eighteen days (Fig. 291 *a*, *b* and *c*). Another procedure which has been described for treating avulsion of the tip of the finger consists of elevating a double pedicle graft on the palmar aspect of the distal phalanx of the finger proximal to the region to be covered. The graft is slid forward into position and sutured. The residual denuded graft bed may be covered by a split skin graft or allowed to heal by granulation and epithelization. In avulsion of skin and soft tissue of the finger tips not involving the bony phalanx the denuded portion may be covered with a split skin graft if sufficient padding to cover the bone is present.

In treatment of avulsion of the tips of several fingers the wall of the abdomen or thorax may be the most efficient donor for the graft. The lower abdominal quadrant opposite the injured member affords an especially convenient donor site. The graft is prepared by a single incision through the skin and s. b.

cutaneous tissue of the desired thickness sufficient undermining is carried out to permit suturing of the fingers under the prepared flap. In treatment of avulsion on the dorsal aspect of the fingers undermining of the abdominal graft is carried laterally and the fingers are placed under the graft and sutured into

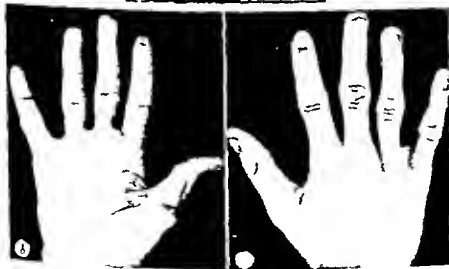


FIG. 91—Immediate employment of single pedicle graft for treating avulsion of the tip of the index finger. *a*, graft in place with pedicle attached; *b* and *c*, postoperative appearance of the fingers.

position. In treatment of avulsion on the palmar aspect of the finger tips or skin and soft tissue over the distal phalanges undermining of the graft is carried medially, the fingers are flexed and inserted under the graft with the dorsal aspect toward the abdomen. Satisfactory postoperative immobilization

the remaining phalanx after removal of the accessory digit. If removal of radially placed accessory thumbs leaves a defect in the capsule on the lateral aspect of the metacarpophalangeal joint repair is necessary. The defect may be repaired by dissecting free a flap of nearby fascial tissue and suturing it to cover the defect (Fig. 290 *a* and *b*).

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In treatment of avulsion of the tips of several fingers the wall of the abdomen or thorax may be the most efficient donor for the graft. The lower abdominal quadrant opposite the injured member affords an especially convenient donor site. The graft is prepared by a single incision through the skin and sub

the usual fashion with a split skin graft. By inserting the hand under this prepared graft, the location of the fingers is determined and slits in the skin and subcutaneous tissue are made to permit extrusion of the fingers. Inasmuch as the second incision of the double pedicle graft is incomplete there is less chance of circulatory embarrassment of the graft. The graft and hand are left in position for a period of three weeks at the end of

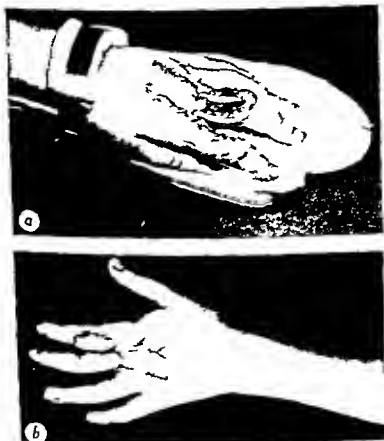


FIG. 93—A ulcer of the soft tissues over the dorsum of the second and third fingers with exposure of the underlying bone: *a* before skin graft *b* appearance after delayed single pedicle graft is in place

which time the graft usually can be severed. In grafting either the palmar or dorsal aspect of the hand, the donor site of the trunk should be opposite to the injured member for comfort to the patient and ease of postoperative immobilization (Fig. 292).

Avulsions of minor degree on the dorsal or palmar aspect of the hand or fingers may be covered by the use of an immediate single pedicle graft; however the double pedicle graft is

usually the graft of choice. The pedicle or pedicles are usually safely severed at the end of three weeks. For older patients who do not require emergency measures, delayed single pedicle grafts may be used more advantageously, especially in those cases of potential infections. For this procedure the wounds and grafts should be prepared in the usual fashion (Fig. 293 *a* and *b*).

Forearm and Elbow—Plastic procedures about the forearm and elbow are most often indicated for closure of ulcerations following burns, healing of recurrent ulceration in scar tissue and release of contracted scars. On the forearm, split skin grafts are satisfactory and suffice in most instances. Pedicle grafts are indicated in treatment of those conditions resulting in exposure of tendons or bone. Scar tissue should be excised completely and split skin grafts should be used to cover the defect unless the scar is unusually soft and pliable in which case contractures can be corrected by plastic incisions (Fig. 294 *a* and *b*).

Axilla—Skin grafts should be applied early to ulcerated fields of any magnitude about the axilla caused by burns or traumatic loss of skin and tissue. In mild cases of contracture of long standing, the scar may be stretched into a pliable web. In these cases good results are obtained from plastic incisions such as the Z incision for release of the web and closure of the defect. An incision is made along the base of the web; this is extended onto the thorax on one surface and on the opposite side of the web along the arm. The two triangular flaps thus created, one with its pedicle attached to the thoracic wall and the other to the arm, are sutured to cover the defects. One flap covers the defect on the arm, the other that on the thoracic wall and axilla. The deep contractures in the axilla must be freed and the scar tissue excised with special care not to damage the important underlying nerves and vessels. Postoperative immobilization with the arm held at right angles should be maintained for three weeks and it is well to maintain the right angle position at night for eight to ten weeks. Stretching exercises should be instituted at the end of three weeks. Abduction humeral splints are advantageously employed for maintaining the right angle position of the arm.

In cases in which webbing is more extensive it is necessary to combine the Z plastic incision with split skin grafts. The Z



Fig. A—See or in notes of the case. The patient is a woman, 35 years of age. The incision on the right hip is a manner similar to that shown in the photograph. The incision on the left hip is a manner similar to that shown in the photograph. The incision on the right hip is a manner similar to that shown in the photograph. The incision on the left hip is a manner similar to that shown in the photograph.

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The flaps are sutured loosely into the residual defects and the remaining defects are filled in with split skin grafts (Fig 29) *a* and *b*)

Incisions along the wall of the thorax and arm may be more advantageously placed if they are made after the splitting and separating of the web rather than before dissection of the web. Postoperative care is similar to that described for the care of split skin grafts and the postoperative routine should be the same as that in which Z plastic incisions are used alone. In the pro

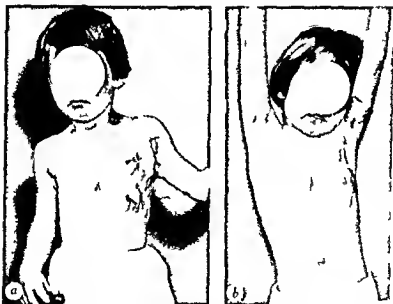


Fig 29 -Webbing of the left arm *a* before operation *b* after repair employing split skin grafts and plastic incisions to utilize maximal length of all proper

cedure of using Z plastic incisions alone or in conjunction with split skin grafts corners or points should be avoided. Cyanotic tissue should be sacrificed inasmuch as any defect can be covered satisfactorily with thick split skin grafts.

Hidradenitis suppurativa of the axilla if it is extensive recurrent or fails to respond to conservative treatment should be treated by wide excision and split skin grafts. The surgical treatment of this condition which has been previously reported consists of a wide excision of the hair bearing tissue and associated ulceration of the surrounding tissue. The excision should

include the deep inflammatory tissue which is easily palpable. The important deep structures of the axilla must be remembered and excision should by no means extend deep enough to jeopardize them. As these infections are of such a chronic nature and frequently do not respond to conservative treatment preliminary preparation of the field is usually futile. After excision of the infected tissue, a split skin graft is removed from the donor site and sutured into position. After operation wet dressings should always be employed and for continuous even pressure and fixation a right angle abduction humeral splint



Fig 296—Chronic hidradenitis suppurativa of the axilla *a* characteristic appearance / appearance one month after excision and repair with split skin graft

should be used. Sulfonamide compounds given orally two to three days before operation and five to seven days after operation may lessen the chance of postoperative complications. The graft should be sprayed with sulfanilamide before application of the final dressings. Unless there is clinical evidence of complication the first dressing should not be done for a period of from five to seven days, and as stated previously soft dressings such as vaselin gauze should be instituted as early as possible. It is well to continue the compression dressings and splints for two to three weeks (Fig 296 *a* and *b*).

The flaps are sutured loosely into the residual defects and the remaining defects are filled in with split skin grafts (fig. 295 *a* and *b*)

Incisions along the wall of the thorax and arm may be more advantageously placed if they are made after the splitting and separating of the web rather than before dissection of the web. Postoperative care is similar to that described for the care of split skin grafts and the postoperative routine should be the same as that in which Z plastic incisions are used alone. In the pro-

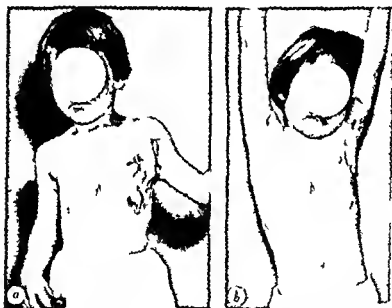


Fig. 295—Webbing of the left axilla. *a* before operation. *b* after repair employing split skin grafts with plastic incisions to utilize normal skin for covering the defect properly.

cedure of using Z plastic incisions alone or in conjunction with split skin grafts, corners or points should be avoided. Cyanotic tissue should be sacrificed inasmuch as any defect can be covered satisfactorily with thick split skin grafts.

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deformity. Many operative procedures have been advised for the treatment of this condition. All of the procedures which have been advocated have features to recommend them and a surgeon in order to be successful should be familiar with all of them. The procedure of choice should be determined from the clinical examination of the foot and roentgenographic findings. Some of the more favored surgical procedures are the Mayo, McBride, Keller, Girdlestone, Silver and Lapidus, all of which are variations in the technical procedures (Figs 297 and 298).

A modification of McBride's operation may be employed successfully in cases of painful bunions with only moderate valgus deformity. Following a simple plastic removal of the excessive portion of bone or exostosis of the medial head of the first metatarsal bone, the adductor hallucis tendon is cut through a small second incision in the web between the first and second toes. In exposing the adductor hallucis tendon, dissection should hug the lateral aspect of the metatarsal head until the tense tendon is palpated. It then is divided and no attempt is made to transplant it. Through this same incision the lateral capsule of the metatarsophalangeal joint may be incised if the valgus position of the toe needs further correction (Fig. 299). In general, bone resections of the Mayo type or its modifications should be used for older persons and persons who have associated arthritic changes in conjunction with hallux valgus.

McBride, in describing his operation, emphasized the fact that if the lateral sesamoid bone is removed, care should be taken to avoid severing the short flexor tendon which might result in a hallux varus deformity.

Tailor Bunion

A painful bursa over the head of the fifth metatarsal bone is a common source of pain and is readily amenable to surgical treatment. Tailor bunions are a result of a prominence of the lateral aspect of the head of the fifth metatarsal bone and the subsequent development of a chronically inflamed bursa. Surgical treatment consists of the removal of the prominent portion of the lateral aspect of the head of the metatarsal bone through a crescent shaped incision with its convexity toward the dorsum of the foot. In the dissection and exposure of the head of the fifth metatarsal bone, the bursa is retained and employed to cover the bony defect. The patient is permitted to wear a

split shoe and begin bearing weight on the foot at the end of ten days after operation. Regular shoes usually can be worn at the end of three weeks.

Soft Corns

Soft corns are the result of pressure from the bony prominences of the phalanges of the toes and may occur at any joint



Fig. 300—*a* Soft corn between the fourth and fifth toes. *b* postoperative roentgenogram in vertical position to demonstrate the prominence of the lateral base of the proximal phalanx of the fifth toe. *c* postoperative view.

level between the toes. The common location is between the fourth and fifth toes and usually in the web at the base of the fourth toe. The soft corn, which in reality is a callus softened from moisture between the toes, is caused by tight shoes which press the medial prominence of the head of the proximal phalanx of the fifth toe against the lateral prominence of the base of the proximal phalanx of the fourth toe (Fig. 300 *a*).

Surgical procedures for this condition consist in removing one of the bony prominences. In the most common location between the fourth and fifth toes the removal of the lateral prominence of the base of the proximal phalanx of the fourth toe is preferable to disturbing the prominence on the fifth toe. Care should be taken to remove the bony prominence cleanly and any spicules attached to the periosteum should be carefully searched for and removed. The capsule should be closed thereby lessening the chances of dislocation (Fig. 300 *b* and *c*). After operation collodion on a cotton dressing suffices to cover the wound, prevents maceration and permits the wearing of loose shoes.

Defects of Soft Tissue

Plastic procedures on the soft tissue about the feet are most often indicated for the relief of chronic conditions. As pre-



FIG. 301.—Ulceration and scarring over the heel *a* preoperative appearance *b* appearance two weeks after operation. The defect was repaired by immediate single pedicle graft.

viously stated pedicle grafts usually are indicated on weight bearing surfaces. In the majority of instances in which grafts

are indicated the problem is usually one of selecting a suitable donor site with a minimum of visible scarring especially in the case of women and maximal comfort to the patient while under treatment. A delayed single pedicle graft except in a few instances is the graft of choice. The details of the procedure have

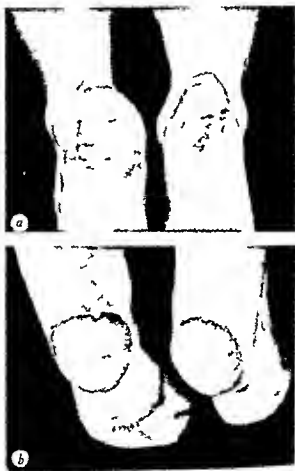


Fig. 30—Extensive lesions involving both heels extending into the weight bearing portions: a before plastic repair; b after repair of defects by delayed single pedicle grafts.

been described previously. Immediate postoperative fixation of the graft is best secured by plaster of paris casts on both extremities. Casts should be applied separately to each extremity to hold them in the desired position. The casts should be applied early enough to permit hardening before attachment of the

pedicle graft to its new site. Windows are placed in the cast over the defect and donor site of the graft to permit attachment of the graft. The casts are then connected, thereby insuring adequate immediate postoperative protection to the transplanted graft.

For the treatment of *decubitus ulcers* of any extent over the heels, immediate single pedicle grafts may be successfully employed. This method of treatment gives months of healing and residual scarring. The necrotic or vascular tissue is excised. An



Fig. 303—Extensive ulceration of the foot *a* before operation *b* after amputation of the fourth toe and repair of the defect by delayed single pedicle graft.

immediate single pedicle graft is elevated from the lateral or medial aspect of the heel and the graft is then rotated into position. It is well to leave as broad a base as possible in the immediate single pedicle graft. Puerling, which occurs at the point of rotation of the graft, disappears on use of the foot after operation. The defect in the bed of the pedicle graft is covered with a split skin graft in the usual fashion. The transplanted grafts should have insured protection from pressure in order to avoid any interruption of circulation. This protection may be afforded adequately by the use of a small piece of balsa or plum wood.

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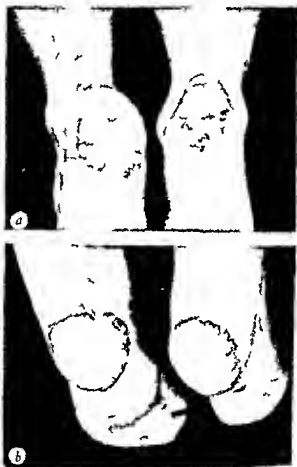


Fig. 307—Extensive lesions involving both heels extending into the light bearing portions *a* before plastic repair *b* after repair of defects by delayed single pedicle grafts

been described previously. Immediate postoperative fixation of the graft is best secured by plaster of paris casts on both extremities. Casts should be applied separately to each extremity to hold them in the desired position. The casts should be applied early enough to permit hardening before attachment of the

of an infection such as osteomyelitis, or in some instances as a result of compound fractures. In this type of case a delayed single pedicle graft or an immediate double pedicle graft which is used as a sliding graft can be employed. If the double pedicle graft is selected it is elevated in the usual fashion, the incisions being so placed that the defect to be covered will be located



Fig 305—Scar involving soft tissue about the lateral aspect of the knee
a before operation *b* three weeks after excision of the scar and repair of the defect by split skin grafts

near the central portion of the graft. The edge of the graft should practically approximate the defect. The defect ulceration or scar is excised and the graft is shifted medially or laterally depending on its location in respect to the defect. The defect from the bed of the graft is covered with a split skin graft in the usual fashion.

Contractures about the knee may be released by plastic in

cision as the Z incision provided the scar presents enough mobility and pliability. However plastic incisions are usually contraindicated. Scarring or bands of contraction should be excised and the defect covered with thick split skin grafts. In those cases in which moderate flexion contracture of the knee is associated the knee should be manipulated into as much extension as is permitted by gentle manipulation before applying the graft (Figs 304 a and b and 305 a and b).

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TREATMENT OF PIGMENTED NEVI OF THE FACE AND NECK

FREDERICK A. FIGI

Pigmented nevi or common moles occur almost universally. Most persons have at least several such skin lesions of varying size. In the great majority of instances the nevi are small, do not cause any trouble and accordingly do not require any treatment. At times, however, because of their extent, situation and prominence they produce considerable disfigurement and removal is desirable for cosmetic reasons. This is true of the pigmented hairy moles often seen about the face and especially of the massive neuromoles at times encountered on the scalp. Both of these lesions, but especially the latter, may attain huge proportions, produce marked deformity and interfere with function to a considerable degree. Fairly frequently, because of repeated trauma, chronic irritation or recurring infection and at times without apparent reason, pigmented nevi undergo malignant change. Because of this, the removal of such lesions as a prophylactic measure often is indicated. Repair of the defect that follows excision of a large nevus may present a difficult problem in plastic surgery.

PATHOLOGIC AND CLINICAL MANIFESTATIONS

Types of Nevi

A pigmented nevus or mole consists essentially of a circumscribed increase of the pigment of the skin. Associated with this pigmentation there usually is hypertrophy of one or all of the other cutaneous elements, especially of the connective tissue and hair. The dermatologist recognizes several different types of nevi. The most common of these are (1) nevus spilus, the simple smooth pigmented cutaneous spot, universally seen; (2) nevus pilosus, the common hairy mole; (3) nevus verrucosus, the mammillated papillary or warty mole; (4) nevus lipomatodes, in which excessive hypertrophy of adipose and connective tissue is present; and (5) linear nevus, which, as the

cision as the Z incision provided the scar presents enough mobility and pliability. However plastic incisions are usually contraindicated. Scarring or bands of contracture should be excised and the defect covered with thick split skin grafts. In those cases in which moderate flexion contracture of the knee is associated the knee should be manipulated into as much extension as is permitted by gentle manipulation before applying the graft (Figs 304 *a* and *b* and 305 *a* and *b*).

RELEVANT ARTICLES NOT REFERRED TO IN THE TEXT

- 1 Barsky A J Plastic Surgery Philadelphia W B Saunders Company 1938 355 pp
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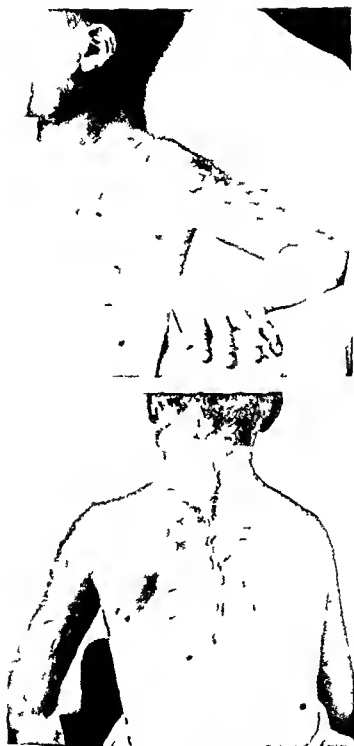


Fig. 506—Extensive pigmented hairy nevus of neck, trunk and arm. Excision and skin grafting of the portion of the tumor on the neck only were advised.

A girl six years of age observed in another state a few years ago had large pigmented hairy moles covering most of the neck trunk and extremities as well as a large part of one side of the face approximately two thirds of the surface of the body being involved

Texture—The texture of pigmented nevi may be like that of the normal skin but as a rule they are firmer more fibrous and thicker than normal are elevated and have a rough hypertrophic papillary or mammillated soft or cornified surface They often present as smooth circumscribed pigmented areas that may or may not be elevated above the surface of the surrounding skin Commonly they are several millimeters in height but some of the neuromoles of the scalp are 3 to 4 cm or more in thickness

Degree of Pigmentation—The degree of pigmentation of cutaneous nevi or moles varies greatly ranging from that of the normal skin to dark brown steel blue and sooty black Their color often remains unchanged throughout life but at times there is a tendency for them to become more deeply pigmented with advancing age and along with this there may be some increase of the size of the lesion and of the number and coarseness of the hairs on the surface In general appreciable increase of the size and of the depth of pigmentation of a mole and especially the change to blue black should be viewed with suspicion particularly if accompanied by local discomfort or tenderness for these may indicate the development of a malignant process

Associated Hair Follicle Infection

Moles generally are asymptomatic and in most cases the patient's only complaint is the disfigurement they produce However recurring infection of the hair follicles of these lesions is fairly frequent especially when the hair is plucked frequently Infection commonly occurs also in papillary nevi and in the large convoluted tumors of the scalp In the latter lesions it tends to flare up acutely at brief intervals The impossibility of maintaining proper hygiene is an important factor in this regard Intense pruritus may be associated with the infection and in the cases of tumors of the scalp pain local tenderness and intermittent fever may be present

mine whether the pigmentation in the lesion of the scalp and that in the pharynx were vascular or melanotic. The patient was anxious to have the tumor about the ear removed as it interfered with her



Fig 307—*a* Congenital deeply pigmented nodular tumor of scalp measuring 10 by 10 by 2 cm. Although the lesion looked like a melanoma, the regional lymph nodes were not palpable. The patient desired removal as this mass interfered with wearing of a headpiece in her work as a telephone operator.

b Diffuse pigmentation of the oropharynx. All was thought to be due to the prolonged use of argyrol nasal packs for sinus trouble.

c Result after excision of tumor of scalp and immediate replacement with full thickness skin graft. The tumor proved to be a melanoma. The patient died four and a half years later of general red metastases.

wearing a headpiece in her work as a telephone operator. The lesion was excised and replaced with a full thickness skin graft (Fig 307 *c*). Microscopically it proved to be a melanoma grade 1. The graft took well and the patient carried on with her work.

for several years. She succumbed to generalized metastasis four and a half years after the operation.

As a matter of fact any method of treatment that cannot be definitely relied on to destroy a pigmented nevus completely with a single application is fraught with danger particularly if the treatment induces appreciable inflammatory reaction. Accordingly radium roentgen therapy, incomplete fulguration and caustics should not be employed for this purpose.

Electrocoagulation or Cauterization

The simplest, most effective and safest method of dealing with small pigmented moles or nevi that is lesions which



Fig. 308—Deeply pigmented nevus which had shown some recent growth. A lesion of this type might be removed readily by means of electrocoagulation but excision is preferable as microscopic study is desirable.

measure up to 5 mm. in diameter is by means of electrocoagulation but it is essential that the lesion be destroyed completely at one time. This is readily carried out as an office procedure with procaine infiltration anesthesia (Fig. 308). If the growth is pedunculated or is raised well above the cutaneous surface it can first be clipped off flush with the skin by means of a pair

of scissors and the denuded area then seared over with the diathermy electrode. As a rule the scar following this is inconspicuous if not actually invisible unless there is a tendency for keloids to develop. Inquiry regarding this should always be made prior to removal of multiple nevi from areas where the presence of a thick scar might cause the patient more concern and inconvenience than the original lesion. In questionable cases it is well to treat only one or two small growths and observe the result some weeks later before one takes care of a number of more extensive ones.

Excision of Nevi with Suture of Wound

After cauterization or electrocoagulation of larger moles (lesions 0.5 to 1 cm in diameter) small depressed scars like those seen after varicella often will remain, particularly if the operator



Fig. 309 — *a* large hairy nevus of cheek, *b* result after simple excision

has made certain to destroy the hair follicles which extend rather deeply. Accordingly when a nevus is more than a few millimeters in diameter and especially if it contains coarse hairs excision with suture of the wound is preferable to diathermy as healing takes place more promptly, complete removal of the hair follicles is more certain and the cosmetic result is better. Care in extending the elliptic excision along the normal cutaneous folds will render the operative scar less conspicuous especially if when the wound is closed the subcutaneous tissues are well supported with fine silk sutures (Fig. 309).



Fig 310—*a* Thick pigmented hairy mole of cheek nose and upper lip *b* result after excision and replacement with full thickness skin graft in stages

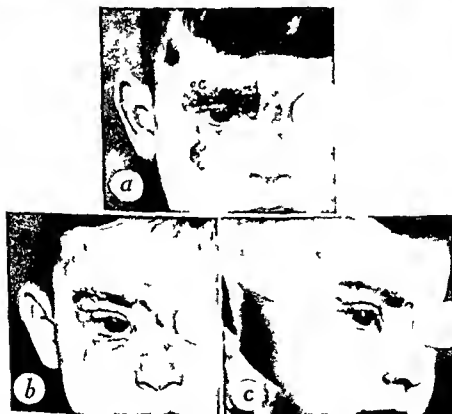


Fig 311—*a* Multiple pigmented papillary hairy moles of face of a boy six years of age in whose case a marked inferiority complex had already developed because of the lesion *b* immediate result after excision and full thickness skin graft in a single stage *c* result one year later

Large Nevi about the Face and Neck

These nevi may be removed by repeated partial excision or they may be excised and replaced with a skin graft in a single stage or multiple stages (Figs 310 to 314). The former pro-

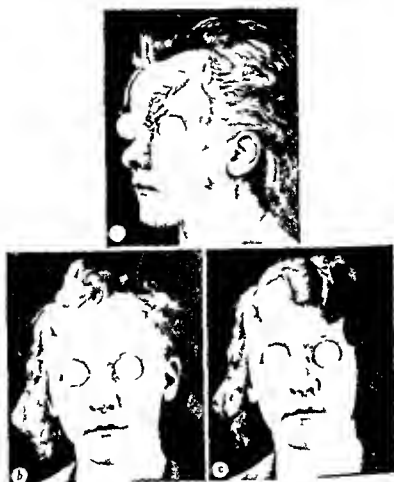


Fig. 31 —a Multiple pilar nevi of face. b and c result after excision with partial suture and full thickness skin grafts in stages. Electrocoagulation of the remnant of the lesion on the nasal ala is carried out later.

cedure often will permit of eradicating nevi of considerable size ultimately leaving only a fine line scar which invariably is much less conspicuous than a skin graft regardless of how well the graft may have taken. According to this plan of attack elliptic portions of the lesion are excised and primary suture of



Fig 314 — Pigmented lesion and application of full-thickness (1st operative procedure)

the wound is carried out and completely removed. The width number of stiches required

tissues the situation on the face or neck and the tendency to produce distortion as the wound is closed. Usually each ellipse is from 2.5 to 3 cm in width and the operative procedures are repeated at intervals of three months or more being spaced at periods of sufficient length to permit stretching of the adjacent skin thereby obviating contracture and deformity.

Naturally this method is not applicable if the nevus is appreciably thickened, highly vascular or infected or if there is any question concerning its being malignant. When these conditions



Fig. 315—*a* Deeply pigmented papillary hairy mole of the lower eyelid and cheek. Grossly the lesion suggests one of a malignant melanoma but there is no enlargement of the regional lymph nodes.

b Result after one stage excision and plastic operation. A flap from the malar region was used to repair the defect in the eyelid and the cheek being covered with a full thickness skin graft.

are present removal in a single stage and immediate replacement with a skin graft or a pedicle flap are advisable (Fig. 315). Many nevi about the face, neck and scalp must be dealt with in this manner.

Large Papillary Nevi about the Ear

An exception to the above generalization concerning the use of a skin graft is encountered in many cases of large papillary nevi about the ear. Many of these lesions involve the preauricular region and the adjacent scalp as well as a large part of

one or both surfaces of the auricle. Because of the irregularity of the surface of the pinna and the small amount of connective tissue between the nevus and the cartilage skin grafts generally do not do well. Accordingly in these cases it often is advisable to remove with the cautery or diathermy electrode a portion or all of the growth on the auricle (Fig 316). The remainder of the lesion on the flat surfaces is excised at the same time and the wound either sutured primarily or skin grafted. Since healing must take place by granulation it necessarily will be slow but unless too large a part of the auricle is denuded at one time



Fig 316—*a* Pigmented papillary nevus of auricle and preauricular region
b result after excision of the portion of the tumor in the preauricular region and electrocoagulation of the part involving the ear

distortion will not occur. Any remnant of the nevus on the auricle will require removal at a later stage.

Pigmented Tumors of the Scalp

In spite of the huge size attained by many tumors of the scalp the embarrassment associated with them, the disagreeable symptoms they produce and the ever present possibility of malignant change often only haphazard and palliative therapeutic measures are advised. This probably indicates that the possibility that surgical removal is feasible is not generally appreciated by the medical profession. Irradiation is contraindicated in these cases as the nevi are highly radioresistant and there is a possibility of

activation of the tumor by such treatment. Moreover irradiation is likely to cause depilation and thus render the lesion more conspicuous (Fig. 317).

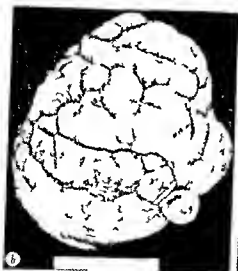


Fig. 317—*a* Extensive fibrous mole of scalp *b* tumor after excision it measured 15 cm in diameter the grafted area on the scalp following removal

Excision and immediate replacement with a free skin graft in a single stage are as a rule readily feasible even though a large portion of the scalp may be involved. This procedure was carried out in several cases in which an extensive neuromole covered a large portion of the scalp. In one instance approximately

half of the scalp and a large area on the face and in another a little more than a third of the scalp were affected. Because of the unusual extent of one of these tumors the case is reported in some detail.

The patient, a man twenty-nine years of age, came for examination because of a large, firm, vascular, fibrous, pigmented mole of

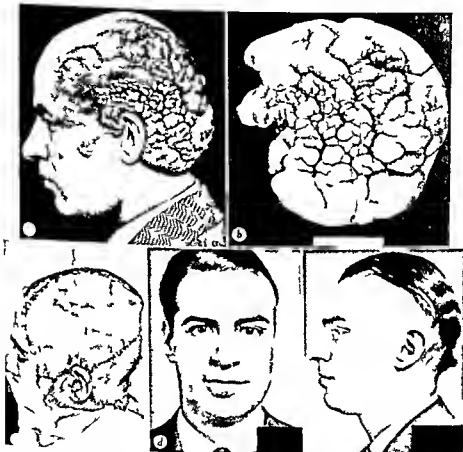


Fig 318—*a* Extensive neuromole of the face, scalp and neck. *b* the excised tumor measured 25 by 22.5 by 4 cm. *c* appearance of skin grafts at time of removal of original dressing twelve days after operation. *d* and *e* later result.

the left side of the face and scalp which had been present since birth (Fig 318 *a*). The tumor had gradually increased in size, had become more nodular and somewhat lighter in color and in recent months had been tender and painful most of the time. Its posterior portion was distinctly convoluted. It measured 25 by 22.5 by 4 cm, covered most of the left temporal, parietal and occipital regions and the posterior part of the cheek and was slightly mov-

THYMIC TUMORS IN MYASTHENIA GRAVIS

O THERON CLAGETT & L. McKENDREE EATON

The interest of surgeons in myasthenia gravis has been stimulated by the report of Blalock, Mason, Morgan and Riven of an apparent cure of this disease by the extirpation of an anterior mediastinal tumor. The patient was operated on in 1936 and at the time of their report had remained free of myasthenic symptoms for about three years after operation. Subsequent reports by Campbell, Fradkin and Lipetz of definite improvement in one case and by Poer of successful treatment in another case of myasthenia gravis by removal of thymic tumors have further aroused the interest of surgeons. Although the report by Turnbull of failure to influence the course of this disease by removal of a thymic tumor tends to temper the enthusiasm of surgeons, it has not lessened their eagerness to share in solving the riddle of myasthenia gravis and its relation to the thymus.

Weigert was the first to suspect a relation between the two diseases when in 1901 he found at necropsy a thymic tumor in a case of myasthenia gravis. Since that time abnormalities in the way of diffuse hyperplasia or actual formation of tumor have been discovered at necropsy with increasing frequency. As Norris stated, "pathologic changes may be found in the thymus in cases of myasthenia gravis in direct ratio to the care with which they are sought." Blalock has been able to collect reports of sixty instances of thymic abnormality verified by necropsy or surgical exploration in 117 cases of myasthenia gravis.

Surgeons became interested in this problem as early as 1917 when the first attempt to treat myasthenia gravis by removal of a thymic tumor was made by Sauerbruch and reported by Schumacher and Roth. Failure to cure the patient completely and the death of two more patients on whom operation was performed by Sauerbruch evidently dampened his enthusiasm and that of other surgeons for this form of treatment. No other reports of wholehearted attempts to remove thymic tumors in myasthenia gravis appeared in the literature until that of Blalock and his associates in 1939.

The critical clinician who has experience in treating a large group of patients suffering from myasthenia gravis will be exceedingly cautious in accepting a remission in any one case of myasthenia gravis following surgical removal of a thymic tumor as evidence of causal relation. He is too familiar with the frequency and unpredictability of remissions in this disorder. Furthermore, he remembers that in many cases of myasthenia gravis in which the patient comes to necropsy there is no detectable abnormality of the thymus. We approve of this skeptical attitude.

Thus far we are aware of only eight cases in the literature in which thymic tumors (not to be confused with persistent or hyperplastic thymic tissue) have been removed surgically in the treatment of myasthenia gravis. In these eight cases three patients died too soon after operation for the effect on the myasthenic symptoms to be observed, leaving only five cases for evaluation from this point of view. Two patients were apparently improved, two experienced complete remissions and one was not benefited. The smallness of this group and the lack of consistent results have left some doubt as to the value of removing thymic tumors in the treatment of myasthenia gravis.

On the other hand, the results in the literature, although inconclusive, are encouraging and previous experiences of members of the Clinic⁵ in securing remissions of myasthenia gravis after roentgen irradiation of mediastinal tumors, presumably of thymic origin, combined to interest us in a study of the problem. Furthermore, it seemed to us that surgical treatment should no longer be extremely hazardous. Effective symptomatic treatment with prostigmine and other drugs,⁴ sulfonamide therapy and bronchoscopy to lessen the danger of pulmonary complications, and the advances in the technic of thoracic surgery and anesthesia should make a surgical attack on this disease much less formidable than in previous years. Therefore, in December 1941, our first patient was subjected to operation.

With the cooperation of the Section on Roentgenology, each myasthenic patient was carefully studied roentgenoscopically and by means of lateral as well as the usual postero-anterior stereoscopic films. We were amazed to find that a much higher percentage of myasthenic patients showed roentgenographic evidence of thymic tumors than our previous experience had led us to expect when only stereoscopic roentgenograms in the

postero anterior position were obtained. In nine of the last fifty five cases there was roentgenographic evidence of anterior mediastinal tumors. In five of the nine cases the abnormal shadow has been verified at operation as representing a thymic tumor. Evidently Norris' statement that thymic abnormalities are found at necropsy in direct proportion to the care with which they are sought may be extended to roentgenographic evidences of thymic abnormalities. They too are found in greater frequency if they are sought for with care and proper technique.

Up to the present time one of us (O. T. C.) has removed four thymic tumors in cases of myasthenia gravis. Another thymic tumor has been removed by Dr. Harrington. In another case in which a thymic tumor was suspected because of a remission of symptoms following roentgen irradiation of the thymic area although there was insufficient evidence on which to base the diagnosis roentgenographically, exploration has been performed and the thymus removed. A tumor was not found in this case. Two patients who had thymic tumors were operated on during remissions apparently induced by roentgen irradiation and they have remained well. In two other cases the course of the myasthenia gravis apparently was not influenced. The fifth patient who had thymic tumor and the patient undergoing thymectomy in whom no tumor was found have been operated on too recently for the results to be evaluated. There have been no deaths and the two patients failing to respond satisfactorily have not been affected deleteriously by the procedure.

PREOPERATIVE CARE

The preoperative management of patients who have myasthenia gravis is extremely important. It is well known that infections, trauma, physical exertion or even nervous strain can cause rather marked exacerbations of myasthenic symptoms. For that reason when surgical intervention is contemplated we have insisted on hospitalization of all these patients for at least two to three days before operation so that the patient can become thoroughly rested and accustomed to hospital routine. This also avoids to some extent the dangers of development of infections of the upper part of the respiratory tract which are so hazardous to patients who have myasthenia gravis. Patients are given sulfadiazine preoperatively in doses of 75 to 90 grains

(5 to 6 gm) daily, for two days before operation. We are convinced that preoperative chemotherapy has reduced materially the risks of surgical intervention in these cases. During the period of hospitalization patients should be given adequate doses of prostigmine so that all myasthenic symptoms are well controlled. All patients should have a blood grouping in case transfusions are necessary during or after the operation.

ANESTHESIA

A mixture of cyclopropane and oxygen administered by the intratracheal route has been our choice of anesthetic agent in all of our cases. This type of anesthesia is flexible and permits a high concentration of oxygen which is important in these cases. The presence of the intratracheal tube makes it possible to aspirate any secretions in the tracheobronchial tree at any time during the operation. Although in some of our cases removal of thymic tumors has been carried out without opening either pleural space there is some danger in opening the pleura in any such operation and the presence of an intratracheal tube with positive pressure anesthesia obviated any dangers from opening the pleura at any time during the operation. Deep anesthesia is not necessary for these operations and it should be avoided.

ROUTE OF APPROACH TO TUMOR

Tumors of the thymus can be approached in a variety of routes and we have tried three different routes so far. In our first case the tumor presented a little to the right of the sternum at the level of the fourth cartilage. A U shaped incision was made in this region and the skin and muscle flaps were turned laterally. Cartilages of the third and fourth ribs were removed the internal mammary vessels were ligated, the pleura was reflected and the anterior mediastinum was exposed. A well circumscribed firm tumor presented immediately. It measured about 6 by 8 cm. The tumor was enucleated without particular difficulty. In the second case the tumor presented to the left of the sternum. Similar exposure was used and worked out very satisfactorily.

In the third and fourth cases the tumor was approached by the transpleural route. A posterolateral incision was made a long segment of the fifth rib was removed the pleura was

opened the lung was deflated and the tumor was removed from the anterior mediastinum.

In the fifth and sixth cases an anterior approach was used. The sternum was split down the middle to the level of the fourth cartilage and then cut out into the third interspace. The split sternum was spread apart and the anterior mediastinum exposed. The thymus was found to be a wide flat tissue lying immediately behind the sternum. The thymus was friable but could be dissected out without particular difficulty. In one of these cases a tumor of the thymus was found as well as hyperplasia of the thymus.

From our experience with these several approaches we are convinced that the anterior sternum splitting approach has some advantages in that it permits thorough exploration of the entire mediastinum from the region a little above the manubrium to the upper part of the pericardium and that this will permit more thorough removal of all thymic tissue than any other approach. By this approach an extrapleural operation can be accomplished. The other approaches that were used permitted satisfactory removal of thymic tumors but it is entirely possible that some active thymic tissue remained and it may be that this remaining thymic tissue is responsible for failure of some patients to be relieved completely of their myasthenic symptoms. It has been our impression that the patients on whom operation has been performed by the transternal route have had more postoperative distress than those on whom operation has been performed by the other routes. However this has not influenced their postoperative course materially.

POSTOPERATIVE CARE

Oxygen is administered to patients for the first thirty six to forty eight hours after operation. Usually at the end of that time oxygen is no longer necessary. For the first day after operation prostigmine is administered parenterally in the same dose that the patient has been taking preoperatively. After that the drug can be administered by mouth as necessary to control any evidence of myasthenia. Chemotherapy is maintained postoperatively until the temperature returns to normal. Postoperative bronchoscopy may be necessary to remove secretions from the tracheobronchial tree. Patients suffering from myasthenia gravis

frequently have difficulty in rusing the secretion and this is particularly true during their immediate postoperative course. Facilities should be readily available for bronchoscopy and it should be done even on what would ordinarily seem rather slight indications. We believe that a respirator of the Drinker type should be available in the management of these patients. Occasionally in these cases severe respiratory failure develops because of the myasthenia and in one of our cases the use of a respirator was responsible for saving a patient who otherwise could not have survived.

In only one of our cases has the postoperative course caused any concern. In this case a tumor was not present. The dissection of the thymus was difficult because of previous roentgen irradiation over the thymus. Postoperatively the patient became prostigmine fast—that is, no longer responded to the use of prostigmine. Severe respiratory embarrassment due to myasthenia developed and it was necessary to place the patient in a Drinker respirator for three days. The patient made an uneventful recovery otherwise and has got along satisfactorily without the use of prostigmine or any of the other drugs usually required by myasthenic patients.

Our results in these five cases of thymic tumor and one case of thymectomy cannot be evaluated completely at the present time. There have been failures but apparently there have been successes too. With increasing experience, the amassing of a larger group of cases and the careful correlation of clinical findings, the histologic picture of the tumors removed and the results may lead to a better understanding of myasthenia gravis and its relation to the thymus.

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TECHNIC OF THYROIDECTOMY

CLAUDE F. DIXON

Surgeons who perform operations for goiter develop a more or less individual routine procedure. The statement has been made that the operation has been so well standardized that nothing can be said that will improve present technic and knowledge of thyroid surgery. To some extent the foregoing statement is true; however, it seems wise never to entertain the belief that the end point in any surgical procedure has been attained.

It is my opinion that the only step in thyroidectomy thus far universally agreed on is the skin incision. The technic of thyroidectomy about to be described is not original; rather, it is the summation of the ideas of other surgeons regarding thyroidectomy plus perhaps an original idea or two.

An experienced surgeon rarely attempts any operative procedure through a small or inadequate incision. Goiter surgery is no exception to this rule. Adequate exposure then should be uppermost in the mind of the surgeon when performing thyroidectomy, just as in other types of surgical procedures.

The technic here illustrated and briefly described may not be the best, but it works.

THE OPERATION

First a collar type of incision is made through the skin and subcutaneous tissue. The anterior jugular veins are clamped, divided, and ligated. Then the deep cervical fascia is incised as was the skin (Fig. 319 *a*). The upper flap (composed of fascia, subcutaneous fat, and skin) is then dissected upward to a point just above the level of the thyroid cartilage. The lower flap is freed in a downward direction to the level of the sternal attachments of the sternocleidomastoid muscles. The prethyroid muscles (sternohyoid and sternothyroid) have thus been exposed and retracted laterally (Fig. 319 *b*). Next the points of dissecting scissors are passed upward behind the thyroid isthmus, beginning at the suprasternal notch, thus freeing the isthmus from

- 6 Norris E H The Thymoma and Thymic Hyperplasia in Myasthenia Gravis with Observations on the General Pathology *Am J Cancer* 27:421-433 (July) 1936
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stress sutures (Fig 324), the inner (mesial) and outer (lateral) borders of the remaining thyroid of the lobe are approximated. Placement of these sutures is a precautionary measure against postoperative hemorrhage from the remaining glandular tissue of the lobe. The insert (Fig 324) illustrates how the lobe has been resected in V shape as well as the relationship between

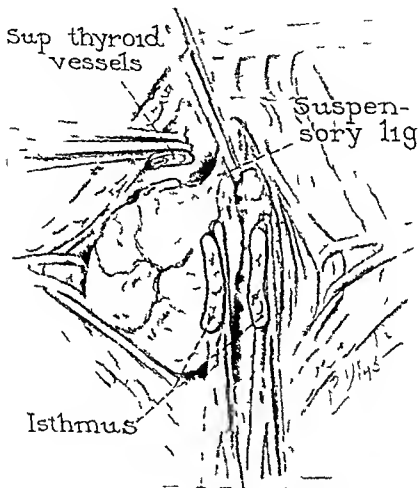


Fig 30—Ligation of right superior thyroid vessels and suspensory ligament
Division of isthmus

the recurrent laryngeal nerve, trachea and posterior aspect of the lobe.

The left lobe is resected in a similar manner. Figure 324 also serves to illustrate the thyroidectomy completed. The sternohyoid and sternothyroid muscles are then brought together by means of a running type of suture. The fascia is approximated by

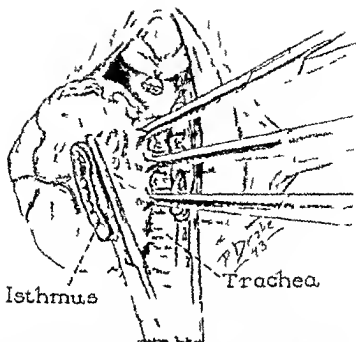


Fig 321—Isthmus retracted laterally to allow clips to be placed on right lobe of thyroid at level of trachea. Broken line indicates first incision on right lobe.

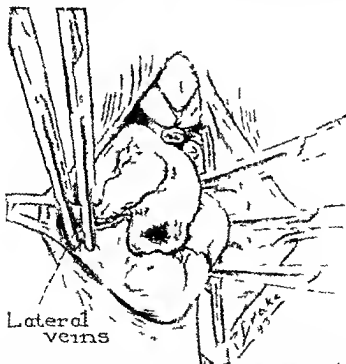


Fig 322—Right lobe retracted medially and lateral veins clamped for ligation.

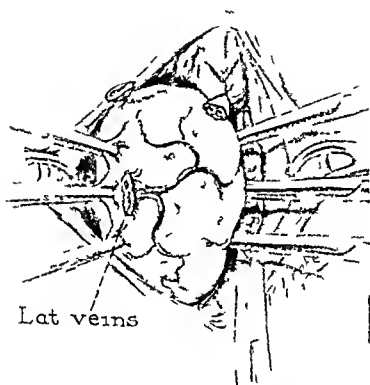


Fig 323—With right lobe rolled medially three clamps are placed far posteriorly to include capsular and glandular vessels. Broken line indicates second incision to complete resection of right lobe.

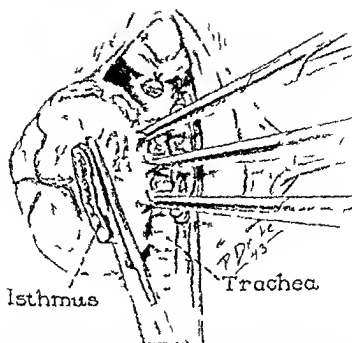


Fig 321.—Isthmus retracted laterally to allow clamps to be placed on right lobe of thyroid at level of trachea. Broken line indicates first incision for resection of right lobe.

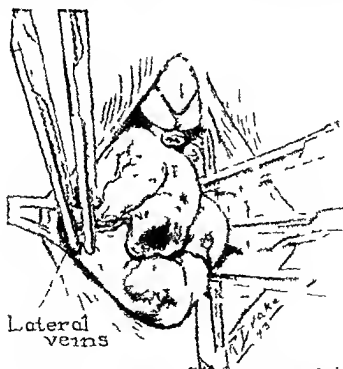


Fig 322.—Right lobe rolled medially and lateral veins clamped for ligation.

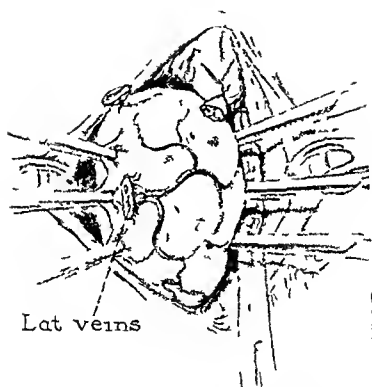


Fig 323—With right lobe rolled medially three clamps are placed far posteriorly to include capsular and glandular vessels. Broken line indicates second incision to complete resection of right lobe.

means of interrupted sutures and the skin incision is closed by means of Michel clips. Usually such wounds are closed without drainage except in cases in which there has been a huge sub-sternal or extremely vascular goiter when a small strip of gauze

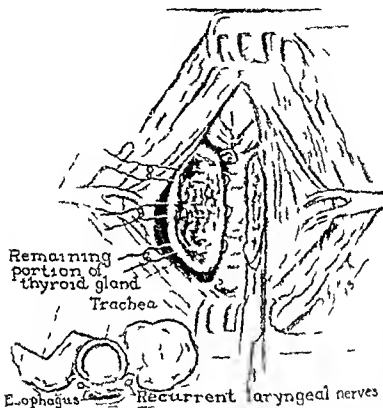


Fig. 34—Thyroid gland resected. Each lobe resected in V shape and anastomosis of the respective right and left lobes. Closure of right lobe made with suture.

is employed for the purpose. Such drains are removed in twenty-four to thirty-six hours after operation.

ANESTHESIA IN THYROID SURGERY

In by far the majority of cases thyroidectomies can be carried out either under cervical block or local infiltration with procaine. It is well I believe to keep in mind that epinephrine never should be added to the local anesthetic agent in thyroid surgery. Epinephrine may bring about a very severe reaction

If the patient is extremely nervous, the anesthesia should be supplemented by inhalation of an agent such as ethylene.

Pemberton has emphasized that regardless of the type of anesthesia employed in surgery of the thyroid the patient should be allowed to awaken following removal of the first lobe. This enables the surgeon to listen to the patient's voice when he is requested to speak or cough. Thereby it can be determined whether the recurrent laryngeal nerve has been impaired. If injury to the nerve occurs during the operation it is well to search along the course of the nerve for the point at which injury occurred. In many instances it will be observed that the nerve has been included in a suture. If the suture is removed function of the nerve can be resumed within a few weeks or months. In all cases in which thyroidectomy is performed at the Clinic laryngoscopic examination of the vocal cords is carried out prior to, and immediately after operation. In cases of recurring goiter two examinations are made prior to operation and the cords are examined again immediately after operation. Obviously if it is found prior to operation that one or the other of the recurrent laryngeal nerves is not functioning properly extra precaution in removing the recurring goiter is in order.

SURGICAL ACCIDENTS

Perhaps the accident which occurs most commonly in the course of thyroidectomy is injury of the recurrent laryngeal nerve as has been mentioned. Of less frequent occurrence is laryngeal spasm. Just why this occurs I am not certain but it may be present without any evidence of injury to the recurrent laryngeal nerves. There is temporary stridor and this condition may necessitate tracheotomy. The condition previously was thought to be due to collapse of the trachea but this condition is rarely responsible according to the experience of those engaged in thyroid surgery at the Clinic. If tracheotomy is necessary in a case of laryngeal spasm the tracheotomy tube usually can be removed in five to seven days.

Hemorrhage

Serious hemorrhage does not often occur in the course of thyroidectomy. In elevating a lobe of the thyroid gland considerable bleeding may be encountered from (1) tearing of the lateral thyroid veins and (2) disturbance of anomalous vessels

Occasionally in operating for recurrent thyroid disease the internal jugular veins may be injured with resulting severe hemorrhage. This is best managed I believe by placing a small gauze pack over the site of bleeding and making no attempt to do more until the lobe has been removed. Invariably such a pack will suffice to stop the bleeding. After the lobe has been resected the pack is taken out and the bleeding vessels are ligated. If an anomalous artery arising from the common carotid is torn it is usually best to deal with the situation at once.

Bleeding rarely occurs postoperatively if the surgeon is particular about hemostasis at the time of thyroidectomy. It is of utmost importance however to keep in mind that postoperative hemorrhage demands immediate attention. Bleeding can most assuredly prove disastrous to the patient. Pemberton has emphasized two or three points which should be kept in mind in regard to postoperative care. The first of these is to make sure that the vocal cords move normally. If laryngoscopic examination reveals no evidence of impairment of nerves and if the patient a few hours after operation has difficulty in swallowing or complains of tightness in the neck or has stridor the bandage should be removed immediately. If there is definite bulging of the wound it is obvious that hemorrhage has occurred under the flap or beneath the muscles and the wound should be opened. An amazingly small amount of bleeding can produce stridor and suffocation of the patient within a comparatively short time.

The second point is that postoperative hemorrhage following removal of a goiter can be prevented in most instances at the time of operation particularly if the patient is made to cough vigorously after removal of each lobe has been completed. Coughing causes increased pressure in the veins about the head and neck and if any of the severed vessels have failed to be ligated bleeding will occur, can be detected and can be stopped.

IMPORTANCE OF POSTOPERATIVE CARE

There is no operation that requires more careful immediate postoperative attention than does thyroidectomy if complications which may prove disastrous are to be prevented.

THE ROLE OF GASTRIC JUICE IN THE EXPERIMENTAL PRODUCTION OF PEPTIC ULCER

CHARLES F. CODE

In the human being the formation of a typical peptic ulcer seldom if ever occurs in the absence of gastric secretion. This simple fact points an incriminating finger at gastric juice as *the factor* in the development of peptic ulcer. If gastric juice produces peptic ulcer it must do so by virtue of its digestive action. The name peptic given to the ulcer in the early days of its clinical recognition emphasized the possible etiologic significance of enzyme action. Today strong evidence can be presented to support the view that it is the acid rather than the pepsin of gastric juice which produces the ulcer. With some justification the ulcer might be designated as acid instead of peptic but reservations are necessary. The impressive quantity of evidence supporting the acid hypothesis may be partly due to the simplicity of determining the acid as compared to the pepsin of gastric juice. Acid and pepsin may properly be considered as a team rather than as separate constituents. Their operation together is rapid and powerful. Separated their digestive action is slow or absent. Argument as to which of the two agents is the more important should not obscure the fact that when gastric juice is absent, typical peptic ulcer is seldom found. The statement suggests the question: Can it be shown experimentally that gastric juice produces peptic ulcer?

Broadly speaking there are two main approaches to the problem. They can be stated best by putting the questions: (1) When the physiologic antagonists of gastric juice are removed does peptic ulcer develop? (2) Will excessive production of gastric secretion produce peptic ulcer?

The vast majority of studies aimed at answering these questions have been carried out on the dog. There are sufficient data on formation of peptic ulcer in this species to allow definite conclusions and satisfactory comparisons to man. For these

reasons the observations to be discussed are confined to those made on dogs

WHEN THE PHYSIOLOGIC ANTAGONISTS OF GASTRIC JUICE ARE REMOVED DOES PEPTIC ULCER DEVELOP?

The physiologic antagonists of gastric juice are the secretions of the *pancreas*, the *liver* and the *duodenum*. They act as antagonists by providing base which combines with the acid. The effect is twofold. Less acid is available for digestive action and as the pH rises peptic action is eliminated. When neutralization has proceeded to about pH 5 it seems safe to consider that gastric digestion has ceased.⁶ Experimentally, as the secretions normally neutralizing gastric juice are diverted from the duodenum there is a progressive increase in the incidence of formation of peptic ulcer.

Abolition of pancreatic secretion by total pancreatectomy seldom if ever results in formation of ulcer (tabulation). Likewise transplantation of the main pancreatic duct to other parts of the bowel with ligation or evulsion of accessory pancreatic ducts has not been found to lead to formation of ulcer in the duodenum.⁶ Duodenal ulcer does however often follow ligation of the pancreatic ducts. Ivy and Fauley found ulcers in six of sixty-one dogs in which they tied off the pancreatic ducts. Sustained total loss of pancreatic secretion from the body by fistula in which there is no obstruction also has been found

lead to duodenal ulceration in a high percentage of animals.^{6, 8, 17} If animals with external pancreatic fistulas are not maintained by administration of salt solution they may rapidly deteriorate and die within about a week without there being sufficient time for development of an ulcer. Failure to obtain ulceration of the duodenum also may be due to the development of obstruction in the fistula or to enlargement or canalization of accessory pancreatic ducts. Such factors may account for failure of ulcers to develop in the experiments of McCaughan, Berg and Jobling and Graves. It seems established that sustained total loss of pancreatic secretion from the body is often followed by formation of ulcer in the duodenum.

The duodenum with its secretion must be considered as one of the factors combating the action of gastric juice (tabulation). Mann and Kawamura and Mann and Williamson found that when the duodenum was removed and replaced by jejunum into

TABULATION
THE OCCURRENCE OF PEPTIC ULCER FOLLOWING LOSS OF THE PHYSIOLOGIC ANTAGONISTS OF GASTRIC JUICE

Anatomic Change	Animals Studied	Animals with Ulcer	Incidence of Ulcer Per Cent	Investigators
1 Loss of pancreatic secretion a By pancreatectomy b By transplantation of pancreatic duct c By ligation of pancreatic ducts d By external pancreatic duct fistula	Many Not stated 61 9 6 Not stated Not stated	Many Not stated 6 0 6 Not stated Not stated	0 0 10 0 100 100 42	Many Graves Ivy and Fauley Berg and Jobling McCaughan Elman and Hartmann Mathews and Dragstedt Hoerner
2 Loss of duodenum by duodenectomy with transplantation of bile and pancreatic ducts into portion of jejunum replacing duodenum	{ 10 10 }	2 2	20 20	Mann and Katsamura Mann and Williamson
3 Loss of bile a By drainage into renal pelvis b By drainage to outside of body Uninterrupted flow of bile Interrupted flow of bile c By obstruction of common bile duct	43 7 11 5 87	17 3 5 2 64	40 43 45 40 73	Kapsnow Berg and Jobling Berg and Jobling Berg and Jobling Bollman and Mann
4 Combinations of losses of pancreatic secretion duodenum and bile a Loss of pancreatic juice and bile by transplantation of ducts in to terminal part of jejunum b Loss of pancreatic juice duodenum and bile by operation of duodenal drainage	{ 31 16 Not stated 20 4 }	10 Not stated 14 Not stated 20 4	32 50 88 95 100 100	Mann and Williamson Mann and Bollman Mann and Williamson Mann and Bollman Morton Ivy and Fauley

which the bile and pancreatic ducts had been transplanted typical chronic peptic ulcers developed in the jejunums of 20 per cent of the animals. Loss of the duodenum is thus accompanied by a distinct tendency towards formation of peptic ulcer.

Complete loss of bile from the duodenum is rather uniformly followed by development of subacute or chronic ulcers in the duodenum (tabulation). It seems to make little difference by what means bile is lost to the duodenum. Kapsinow drained the bile from the duodenum by anastomosing the gallbladder to the pelvis of the right kidney and ligating the common bile duct. Typical duodenal ulcer developed in seventeen of his forty-three animals. Berg and Jobling drained the bile to the outside of the body by means of biliary fistulas. In some instances drainage was continuous, in some intermittent and in some was completely obstructed. Despite these differences duodenal ulcers developed in 40 to 45 per cent of their animals. Bollman and Mann studied a series of eighty-seven dogs with complete obstructive jaundice induced by ligation and section of the common bile duct. In sixty-four (73 per cent) of the animals in their group acute, subacute or chronic peptic ulcer of the duodenum or stomach developed. The great majority of the animals had chronic ulcers in the duodenum. It is certainly established that when the duodenum is deprived of bile ulcer develops in a high percentage of animals.

Combinations of the loss of these three primary antiastric juice factors have been extensively studied by Mann and his coworkers (tabulation). Mann and Williamson and Mann and Bollman reported that loss of pancreatic juice and bile from the duodenum brought about by transplantation of the ducts to the terminal portion of the ileum results in formation of ulcer in 32 to 50 per cent of the animals. Finally simultaneous loss of the three factors pancreatic juice, duodenum and bile is almost invariably followed by formation of ulcer.¹⁴⁻¹⁶ This observation has been repeatedly confirmed.¹¹⁻¹⁷⁻¹⁹ Thus it is established that when the physiologic antagonists of gastric juice are removed peptic ulcer will develop.

It must be admitted that removal of one or more of the secretions opposing the digestive action of gastric juice may produce changes in the general health of the animal. Ivy²⁰⁻²² in his early studies emphasized the importance of such general factors as nutritional and digestive disturbances in the etiology of experi-

mental peptic ulcer Ulcer produced by ligation or external drainage of the bile or pancreatic ducts may involve such factors although it is doubtful whether they are of prime importance The operation of duodenal drainage in which the digestive secretions of the duodenum pancreas and liver are drained into the terminal part of the ileum must somewhat alter digestion although apparently the nutrition of the animal does not decline appreciably until the ulcer in the jejunum has become chronic^{18 19} Nevertheless the conviction arises that the concept of formation of peptic ulcer developed from the evidence so far presented would be strengthened if typical ulcers could be produced experimentally in an undisturbed gastrointestinal tract If the concept presented is correct the method to be used in fulfilling this requirement is the production of overwhelming amounts of gastric juice

WILL EXCESSIVE PRODUCTION OF GASTRIC SECRETION PRODUCE PEPTIC ULCER?

An early approach to this phase of the problem was made by Silbermann He carried out experiments in which excessive gastric secretion was induced by *sham feeding* Esophagotomy was performed on twenty three dogs Both ends of the sectioned esophagus were brought to the skin in the neck Food taken by mouth did not reach the stomach Between sham feedings the animals were fed by stomach tube Sham feedings consisting of meat bouillon and bread were started a few days after operation In five of the animals sham feeding responses did not develop and the animals died ten to thirteen days after operation without showing changes in the stomach or duodenum Energetic responses developed in the remaining eighteen and they were sham fed three times a day on an empty stomach for periods ranging from fourteen to forty seven days when necropsy was made Some changes were observed in the mucosa of the stomach or duodenum of all of the animals These ranged from mucosal defects and multiple superficial erosions to subserous and deep ulcers (Silbermann used the term 'subserous ulcer' He did not define it) All of the more definite ulcers occurred in the latter weeks of the experiment Mathews and Drigstedt repeated the experiment with three dogs which had esophageal fistulas to prevent food taken orally from reaching the stomach and on which gastrostomy had been performed

for ordinary feeding. They sham fed their dogs once a day for a month. At the end of this time there were no ulcers in any of the dogs. They may not have sham fed their animals long enough and often enough to have obtained overwhelming amounts of gastric juice. Their results indicate however that utilization of the sham feeding response is not an easy simple method of obtaining peptic ulceration.

Administration of histamine produces prompt secretion of gastric juice. The juice has a high concentration of hydrochloric acid and contains significant quantities of pepsin.³ There is considerable evidence that histamine may play a role in the normal process of gastric secretion.³ Sufficiently small quantities of histamine may be administered so that its secretagogue effects alone are in evidence. Histamine therefore offers a means of producing excessive gastric secretion in intact animals through what appear to be physiologic channels.

The gastric secretory action of histamine injected into the body in watery solution is of short duration. If excessive secretion is to be maintained repeated injection must be made. Orndorff, Bergh and Ivy have used this method in an extensive study with the dog. Nine animals were given 7 mg. of histamine every two hours for twenty hours of each day during periods ranging from fifty five to sixty six days. The investigators found small acute erosions in the duodenal mucosa of four dogs but in no case was a chronic ulcer produced.

Varco and I have devised a method whereby the action of single injections of histamine may be greatly prolonged. Finely powdered histamine is suspended in a mixture of beeswax and mineral oil or beeswax and sesame oil. The mixture is a soft waxy solid at ordinary room temperature and can be injected easily through a 20 gauge needle. When placed beneath the skin it remains as a semisolid mass from which the histamine is slowly absorbed. The mixture of wax and oil apparently gives a protective coating to the particles of histamine. The secretion of juice from gastric pouches in response to injections of this mixture has been used as an indication of the intensity and duration of the histamine action. In response to single doses of 15 to 30 mg. of histamine in the beeswax mixture gastric pouches are stimulated for periods of twenty four or more hours and yield quantities of juice ranging from 680 to 1350 cc. equivalent to about 1 to 2 liters of tenth normal hydrochloric acid. The action

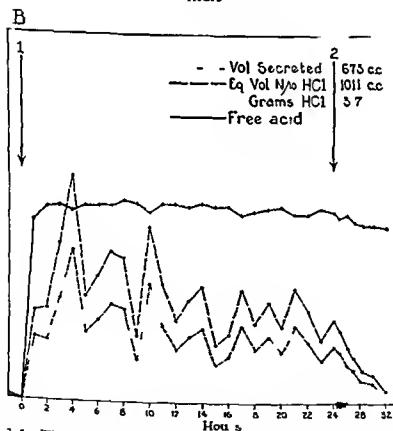
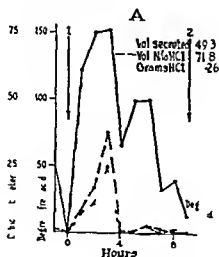


Fig 3 5.—The gastric secretory response from a Heidenhain gastric pouch in a dog. At arrow 1 in A 30 mg of histamine in watery solution was injected. At arrow 1 in B 30 mg of histamine in the beeswax mixture was injected. The total volume and hydrochloric acid content of the juice secreted during the periods of observation are indicated at arrow 2.

of similar doses of histamine in watery solution is usually completed within four hours and the quantity of juice secreted is

generally less than 100 cc (Fig 325) Placing the histamine in the beeswax mixture gives a much more efficient action Such large doses of histamine when given in watery solution to dogs produce severe shocklike reactions when given in beeswax there is usually no reaction a copious flow of gastric juice being the only obvious sign of histamine action

If a pouch of only a small part of the stomach will yield a liter of highly acid gastric juice in response to an injection of histamine in beeswax the whole stomach must give even greater quantities The procedure offers a means of testing whether or not excessive gastric secretion will produce chronic



Fig 3 6--Single chronic perforating duodenal ulcer 1.5 cm distal to the pylorus in a dog which received 30 to 40 mg of 1 stamine in beeswax mixture per day for twenty eight days

peptic ulcer in the intact dog Varco Walpole Wangensteen and I first tested it with three normal healthy dogs The animals received single daily intramuscular injections of 30 to 40 mg of histamine in the beeswax mixture One of the animals was examined at the end of four days the other two at the end of twenty three and twenty eight days respectively Two of the animals had single and one of the animals multiple perforating ulcers 1 to 1½ inches (2.5 to 3.8 cm) in diameter in the first part of the duodenum (Fig 376) Hay Varco Wangensteen and I extended these observations We gave daily injections of 30 mg of histamine in the beeswax mixture to thirteen dogs for periods of four to thirty seven days In eight

of the animals duodenal ulcers developed four of the animals had gastric ulcers and in the remaining animal no ulcer was found. As a control to these observations the beeswax oil mixture with *no* histamine in it has been given daily to dogs for periods of one month without effect on the gastro intestinal tract. In addition 30 mg of histamine in the beeswax mixture was given daily for thirty days to one dog from which the stomach had been removed. At the end of this period no ulcers were found in the gastro intestinal tract. It seems established that the ulcers produced in the intact dogs were due to the continuous excessive secretion of gastric juice evoked by the histamine in the beeswax mixture. The experiments offer clear cut evidence that excessive gastric secretion will produce typical peptic ulcer.

It should be emphasized that the acidity of the gastric juice secreted in response to the histamine was high but not beyond that which may be given by Pavlov pouches in response to a meal. There was pathologic hypersecretion following the injection of histamine in beeswax but the juice was not pathologically hyperacid. The data indicate that it was the continuous excessive production of acid gastric juice which produced the ulcers. The difference between the results obtained by Orndorff, Bergh and Ivy using histamine in watery solution and those obtained with the use of histamine in beeswax is probably due to the continuous more or less constant secretion of gastric juice given by histamine in beeswax in contrast to the more fluctuating response given by histamine in watery solution.

CONCLUSION

It may now be said with certainty that in the dog peptic ulcer will develop when acid gastric juice is unopposed or is produced in overwhelming quantities. The site at which the ulcer will develop seems to depend on the trauma incident to the movement of material through the gastro intestinal tract and on the resistance of the various portions of the gastro intestinal tract to the digestive action of gastric juice.^{11 13 14 17 19} The most important single factor however remains acid gastric juice. Experimentally peptic ulcer will develop when the antagonists of acid gastric juice are inadequate or when the production of acid gastric juice is excessive.

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THE INFLUENCE OF DIET ON THE RESISTANCE TO EXPERIMENTAL HEPATITIS

JESSE L. BOLLMAN

Fatty infiltration degeneration necrosis and cirrhosis of the liver may develop in animals fed diets deficient in one or more specific types of foodstuff and the inclusion of this factor in the diet may prevent hepatic injury or restore the previously injured liver. Some substances as is the case with cystine may produce degeneration and cirrhosis when present in excess as well as when a deficiency is present. Additional exposure to mild or severe hepatotoxic agents like alcohol chloroform or carbon tetrachloride has also been used to demonstrate the protective value of certain substances or the lowered resistance of the liver when certain deficiencies exist. There is no evidence available which would indicate the presence or absence of a common factor in the various injuries to the liver produced by disease hepatotoxic agents or dietary deficiencies. For the present it is necessary to limit the conclusion drawn from experimental studies of the protection of the liver by replacement of deficiencies or the addition of other substances to the type of experiment under discussion. The many interesting facts concerning the resistance of the liver accumulated in recent years give rise to the hope that a clearer concept of the detoxicating function of the liver will soon be developed.

Marked changes occur in the chemical composition and microscopic appearance of the liver under normal conditions with relation to the taking of food. Such variations within the day are most marked in animals receiving their food once each day. The glycogen content of the liver is elevated more than ten times the fasting level in the first few hours after the animal takes the meal. Shortly after digestion is complete the glycogen content of the liver again decreases rapidly and later there is a small increase and a slow decrease to the fasting level. Respiratory data indicate that the fasting animal is deriving most of its energy from fat whereas shortly after a

meal containing carbohydrate most of the energy is derived from carbohydrate. Utilization of protein is greatest when the excess carbohydrate has been removed. The appearance of acetone bodies during fasting suggests that different pathways with different end products are utilized in the presence of different nutritive conditions.

Since the liver is responsible for many of the changes which occur in the utilization of foodstuffs it is probable that its response to toxic agents would vary with the nature and amounts of foodstuffs present. Mann and I¹⁻³ have many times noted that the reaction to toxic agents from the viewpoint both of systemic reaction and of the injury produced in the liver varied with the diet of the animal and the chemical composition of the liver. This difference can be very marked as has been shown with dogs fed a diet containing carbohydrate once daily and given equal amounts of tetrachlorethane at different times after feeding. The amount of tetrachlorethane that produces marked intoxication and coma of six or eight hours duration when administered twenty four hours after the last feeding produces only a slight intoxication when given twelve hours after feeding and does not produce any visible effect when given one to six hours after the meal. The lesions produced in the liver by this drug are also proportional to its systemic effect.

Much larger variations of the chemical composition of the liver may be produced in animals maintained on isocaloric diets containing varied proportions of carbohydrate, protein and fat. The absence of certain accessory substances will also produce marked changes of the amount of glycogen and fat found in the liver. The presence of hepatitis as in the experiments reported in this paper reduces the storage capacity of the liver so that the actual chemical composition of the liver with the different diets used was found to be somewhat similar to that of fasting animals. The glycogen content was low and the fat content was somewhat increased. The amount of carbohydrate, protein and fat processed by the liver each day must have been the same as the dietary content of these substances. The differences in the resistance of the different groups of animals to repeated exposure to carbon tetrachloride may be ascribed to differences of the liver metabolizing different proportions of carbohydrate, protein and fat.

Butt, Snell and I⁴ have observed that rats exposed repeatedly

to carbon tetrachloride died with massive accumulation of blood in the gastro-intestinal tract and that the prothrombin content of the plasma was at extremely low levels. Concentrates of alfalfa rich in vitamin K and synthetic compounds having effects like those of vitamin K were administered to these animals and in all cases failed to increase the level of prothrombin in the circulating blood. A detailed study of the possible causes for such failures indicated that the only common factor was the association of extensive hepatic injury with the depletion of the level of prothrombin and also with the failure of response to vitamin K. In this series the immediate cause of death after repeated exposure to carbon tetrachloride has been gastro-intestinal hemorrhage due to prothrombin deficiency which was the result of hepatic damage.

EXPERIMENTAL PROCEDURE

Male white rats (Wistar strain) weighing approximately 200 gm each were fed a basic diet which contained 44 parts of lean meat 44 parts of cracker meal 8 parts of lard and 4 parts of salt mixture and vitamin supplements. Rats take 20 gm of this diet daily and remain in normal appearing condition for periods of more than two years. The rats used in these experiments were kept in individual cages and any uneaten portion of the food was reweighed each day. The foregoing diet was termed a mixed diet and was fed in amounts of 20 gm daily. In the experiments of series A each animal received 10 gm of the mixed diet to which was added 7 gm of cracker meal for the carbohydrate diet 10 gm of meat for the protein diet or 3 gm of lard for the fat diet. The amounts fed were isocaloric. It should be noted that in series A all rats received 10 gm of the mixed diet which contains approximately the caloric requirement for their basal metabolism. With the addition of carbohydrate protein or fat in the amounts fed normal rats gained weight and lived at least one year. In the experiments of series B the animals received 5 gm of the mixed diet to which was added 11 gm of cracker meal for the carbohydrate diet 15 gm of meat for the protein diet or 5 gm of lard for the fat diet. In the experiments of series C the animals received 5 gm of the mixed diet to which was added 11 gm of sucrose for the carbohydrate diet 11 gm of casein for the protein diet and 2.5 gm of lard with 5.5 gm of sucrose for the fat carbo

hydrate diet. All these diets were adequate to maintain normal rats indefinitely except the series B fat diet on which the animals lost their appetite after a few months and lived only about four months.

The rats were placed in a closed chamber and exposed to a continuous stream of carbon tetrachloride vapor for thirty minutes three times each week as long as they survived. All the rats in each series were exposed to carbon tetrachloride in the chamber at one time so that equal exposure of each rat was insured. A uniform concentration of carbon tetrachloride vapor was maintained by vaporizing 1 cc. of carbon tetrachloride in 10 liters of air passed through the chamber each minute. The rats were semiconscious at the end of each exposure but recovered rapidly when returned to their cages in air.

EXPERIMENTAL RESULTS

The duration of life after the inception of the exposure to carbon tetrachloride three times each week is given in Table 1.

TABLE 1
CARBON TETRACHLORIDE REGIMEN RATS DYING FROM HEMORRHAGE

Diet	Rats	Average Duration of Life Days	Percentage of Diet Taken	Protective Value of Diet
Mixed	177	35.7	82.1	100
Carbohydrate A	86	46.5	80.0	130
Protein A	115	31.7	81.2	89
Fat A	125	29.1	69.0	81
Carbohydrate B	24	94.1	91.7	264
Protein B	36	47.9	97.3	134
Fat B	49	27.0	78.6	76
Carbohydrate C	12	109.4	91.0	306
Protein C	19	52.8	86.6	148
Fat-carbohydrate C	27	52.6	85.7	147

The numbers given in the column headed "Protective value of diet" are obtained by dividing the average duration of life of rats

receiving a given diet by the average duration of life of rats receiving the mixed diet. The animals included in this table were allowed to die without any additional procedures being made. A few animals refused their food shortly after exposure to carbon tetrachloride and died after a few days. This refusal of the diet was rare and did not seem to be dependent on the nature of the diet given. Accordingly, such animals were not included in the figures given. There was considerable variation of the survival time of the animals on each of the different diets but the figure given for the average duration of life is significant. The number of days when half of the animals in each group have died is almost the same as the average duration of life. The index of the protective value of the diet obtained by dividing the period when the first 70 per cent of rats receiving a given diet have died by the corresponding period for rats receiving the mixed diet is approximately the same as the index of the protective value of the diet given in Table I. Almost the same figure is found when the days until 80 per cent of the rats have died are compared.

The amount of food consumed each day was limited by the amount fed so that the average amount of food consumed was less than would be taken by rats not receiving carbon tetrachloride. The figure for the percentage of the diet taken is the average of the food consumption for the entire period of survival. The consumption of food was fairly constant from week to week except for the last week of life when it was usually much reduced. In this series there was little relation between the quantity of food taken and the duration of life. The rats that took more than the average amount of food in each group did not live significantly longer than the average length of life for each group. In most cases the animals consumed all of their food each day and when food was left uneaten it was usually an indication that the animal was not doing well. Since the amount of food each day was limited there was no opportunity to regain the food not taken on other days. The lack of correlation between the quantity of food taken and the duration of life is accounted for largely by the fact that the average figure does not indicate that all of the food was consumed on most days and less was taken only at regular intervals. Other experiments in which the quantity of food has been limited to less each day than the amount fed in this series clearly indicated

that the resistance of the animals to carbon tetrachloride was less than in this series

The rats receiving the high carbohydrate low protein and low fat diets survived the repeated exposure to carbon tetrachloride much longer than those on any of the other diets. The rats receiving the high protein diet of the B and C series also seemed to be somewhat more resistant. The added protection of the protein may have been due to that portion of protein converted to glucose. Approximately the same protection was afforded with the low protein diet of series C when half of the fat of the diet was replaced with an isocaloric amount of sucrose.

Although gross hemorrhage into the intestine was a prominent feature in the condition found at necropsy, microscopic examination of sections from the intestine did not show evidence of bleeding from large vessels. Petechial hemorrhages were observed in the capillaries of the mucosa in all animals. In many these were confined to the capillaries of the jejunum but in others bleeding from almost all of the mucosal capillaries was observed. In a few animals hemorrhage was also present in the stomach and in the colon but the greatest changes were always found in the jejunum. Capillary hemorrhage was also frequently found in other organs to a lesser degree than in the intestine. Listed in order of the magnitude of the bleeding observed microscopically, these organs are the liver, kidney, lung, adrenal and pancreas. A few petechial hemorrhages were found occasionally in the heart and skeletal muscle.

The only organ that showed cellular degeneration other than that immediately associated with hemorrhage at the time of death after the carbon tetrachloride regimen was the liver. Extensive necrosis was present in this organ and it was usually difficult to find any hepatic cells which did not show evidence of degeneration. Usually there remained only a few cells that could be recognized as hepatic cells. In the animals that survived for longer periods there were accumulations of connective tissue and much distortion of the architecture of the liver which indicated that some regeneration of the previously damaged liver had occurred but that the new hepatic cells were later killed by subsequent exposure to carbon tetrachloride. In the animals studied at the time of death no differences in the extent of degeneration of the liver could be observed which could be ascribed to the different diets taken by the animals.

Microscopic examination of sections of liver taken from rats killed at various times during the carbon tetrachloride regimen showed some evidence of the protective effects of the diet. Because of the severity of the regimen all of the livers were extensively damaged after the first week and the differences of appearance with the different diets used were small compared with what might have been expected from the differences of the times of survival of the animals on the different diets. At the same time intervals the greatest amount of necrosis was usually found in the livers of rats fed the fat diets and the least in the animals fed the carbohydrate diet. In some instances the differences were very marked but in others no choice could be made. However, when a difference was present in comparable animals it was always in favor of the carbohydrate fed animals showing the lesser amount of necrosis. Regenerative changes in the liver as indicated by the number and size of the round islands of regenerated hepatic cells were most marked in the protein fed animals. In most instances these islands of regenerated liver cells stained more deeply and did not show as extensive degenerative changes as were found in the other parts of the same liver or were present in the livers of comparable rats on other diets.

There was extensive hepatic degeneration in all of the animals of this series and no correlation could be established between the histologic appearance of the liver and the lowered prothrombin content of the blood. Definite hepatic degeneration could be demonstrated shortly after the first exposure to carbon tetrachloride and there was some loss of the prothrombin from the blood. Levels of prothrombin of less than 20 per cent usually occurred after about three weeks of the regimen at which time the histologic appearance of the hepatic degeneration was not much more extensive than that found after a few days. The development of hemorrhagic changes occurred without further reduction of the prothrombin content of the blood and with slightly more extensive damage apparent in the liver.

Chemical analysis of the livers taken at different times during the regimen failed to show any correlation with the type of diet used during the time of the regimen. In all animals carbon tetrachloride produced a marked lowering of the glycogen content of the liver, only 10 to 20 per cent of the amount found in the livers of untreated animals receiving similar diets. The

neutral fat content of the liver was increased and was usually greatest in the fat fed animals. No marked changes were found in the phospholipids of the liver. In other experiments it was found that the glycogen content of the liver could be increased a few hours after the administration of glucose by stomach tube but the glycogen content was less than that of animals receiving glucose but not receiving carbon tetrachloride. The daily administration of glucose by stomach tube did not prolong the life of any of the animals beyond that of those receiving the carbohydrate diet.

COMMENT

It should be noted that in all of these experiments the procedure used produced extensive damage to the liver. The paucity of differences noted in the histologic picture of sections of the liver from animals on different diets were due largely to the severity of the procedure. The repetition of the injury three times each week also may have had a cumulative effect which would mask differences that might be present after a single exposure. Much greater differences in hepatic damage and survival are rapidly evident when diets deficient in carbohydrate or protein are used than when diets containing an adequate amount of carbohydrate or protein are used. However in the experiments reported here all the diets contained slightly more of these substances than is necessary for the basal metabolism of the animal and amounts of carbohydrate, protein or fat were added to provide additional caloric intake for the activity of the animals. Animals not exposed to carbon tetrachloride lived in normal appearing conditions when these diets were fed.

The diets employed in this series were all isocaloric and with few exceptions the animals consumed almost all of the diet given. The amount fed was almost the upper limit that would be taken by rats receiving carbon tetrachloride although the average daily intake could probably have been increased by allowing free access to food. Other experiments indicate that lowered caloric intake decreases the resistance of the liver to carbon tetrachloride. It is probable that additional caloric intake might increase the resistance of the liver. In the light of these experiments additional caloric intake from carbohydrate should increase the resistance more than would the same caloric intake

of protein whereas the added caloric intake from fat would probably have little effect. The protective value of carbohydrate appears to be about twice that of protein when sufficient protein is already present in the diet to provide sufficient and necessary amino acids for reparative purposes.

There is no assurance that the same diets which afford protection to rats against experimental hepatitis produced by carbon tetrachloride would be as effective when other hepatotoxic agents were used. It is probable that agents which produce irreparable damage to the liver would not be influenced by dietary differences. It is also probable that the influences of the quality of the diet on the course of disease of the human liver differ from those of rats receiving carbon tetrachloride. However, from the results of these and other experiments with animals and with disease of the human liver, the following suggestions may be made for trial in the treatment of patients. The caloric value of the diet should be as high as possible and to further this end all possible means of increasing the appetite should be employed. Because of the impaired storage facilities of the liver, four meals a day should be given at approximately six hour intervals. The ratio of carbohydrate and protein in the diet seems to be of less importance than the total caloric intake furnished by these substances. Additional calories furnished by fat in excess of approximately 10 per cent of the diet do not seem to have much protective value. Sufficient protein should be given to furnish amino acids necessary for body maintenance and repair. Additional calories furnished by carbohydrate seem to offer the greatest protection to the liver. The vitamin content of the diet should also be adequate.

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of protein whereas the added caloric intake from fat would probably have little effect. The protective value of carbohydrate appears to be about twice that of protein when sufficient protein is already present in the diet to provide sufficient and necessary amino acids for reparative purposes.

There is no assurance that the same diets which afford protection to rats against experimental hepatitis produced by carbon tetrachloride would be as effective when other hepatotoxic agents were used. It is probable that agents which produce irreparable damage to the liver would not be influenced by dietary differences. It is also probable that the influences of the quality of the diet on the course of disease of the human liver differ from those of rats receiving carbon tetrachloride. However, from the results of these and other experiments with animals and with disease of the human liver, the following suggestions may be made for trial in the treatment of patients. The caloric value of the diet should be as high as possible and to further this end all possible means of increasing the appetite should be employed. Because of the impaired storage³ facilities of the liver, four meals a day should be given at approximately six hour intervals. The ratio of carbohydrate and protein in the diet seems to be of less importance than the total caloric intake furnished by these substances. Additional calories furnished by fat in excess of approximately 10 per cent of the diet do not seem to have much protective value. Sufficient protein should be given to furnish amino acids necessary for body maintenance and repair. Additional calories furnished by carbohydrate seem to offer the greatest protection to the liver. The vitamin content of the diet should also be adequate.

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TYPES OF ACTIVITY OF THE NORMAL INTESTINE

The movements of the intestine may be very complicated and records of them regardless of the manner in which they are obtained often defy analysis. While many types of intestinal movements have been described the following appear to be those acceptable to most physiologists: rhythmic segmentation, peristaltic waves, peristaltic rush, tonus waves, pendular movement and antiperistalsis. Each of these types of intestinal movements has been observed in the exteriorized loop of the trained dog in our experiments but it has often been difficult to recognize the two last mentioned.

Rhythmic segmentation is the most interesting type of intestinal movement and the one which has received the most study. Douglas and I found that this type of movement is not as common in the type of preparation that we studied as investigations on the isolated loop of intestine would indicate. Our observations corroborated the gradient hypothesis of Alvarez^{1, 2} that is the rate of any given loop was found to be a function of its distance from the pylorus, the loop at the highest level having the highest rate, that at the lowest level having the lowest rate. We also corroborated the findings of Puestow and Castleton that the rate of contraction was a constant for any given loop with a variation of ± 1 contraction per minute. As a matter of fact we found that the rate of contraction in rhythmic segmentation of a specific loop of intestine was one of the most constant of the rhythmic activities of the body and furthermore until the present time we have not been able to change the rate of any given loop in continuity by any of the procedures or drugs tried. The rate was not affected by feeding, fasting, sleep, degenerative vagal and splanchnic section or procedures and drugs to be mentioned later.

THE DAILY CYCLE OF INTESTINAL ACTIVITY

The results of our studies on the daily cycle of intestinal activity made for the purpose of establishing a series of normal records with which to compare records obtained in subsequent studies were somewhat disappointing. We had anticipated from the results of studies made by means of a barium meal that the intestine would become quiescent before the end of the twenty-four hour period after the ingestion of a meal. Observations made on the exteriorized loops of intestine showed

However the ingestion of the barium meal or the insertion of a balloon stimulates the intestine making it impossible to observe the activity of the intestine under normal basal conditions by these methods

A preparation developed in our laboratory a few years ago proved suitable for our purposes³ The operative procedure involved in making this preparation consists in exteriorizing the desired loop of intestine and covering it with a bipedicle tube of silastic leaving the loop in continuity with mesenteric blood and nerve supply intact The movement of such an exteriorized silastic covered loop of intestine is identical as nearly as can be determined with the activity of the intestine in its normal position within the abdominal cavity This method provides a means of studying the motor mechanism of the intestine in some physiologic states and pathologic conditions which it is not possible to study with other methods It is particularly valuable for studies on the trained animal under standard basal conditions Not only can the activity of the loop be observed but also it can be recorded with suitable apparatus

In our first experiments in order to study the daily cycle of activity of the intestine control records were made of the movements of the intestine the animal was then fed and more or less continuous records were made during the following twenty four hours While this procedure did supply records of intestinal activity during the normal daily cycle it was found that the intestine did not become sufficiently quiescent between meals for the purposes of some of our studies For such studies the following standard procedure was adopted and was rarely modified except in certain details to make it more suitable for specific problems

All animals were trained to lie quietly on the observation table for as long a period as necessary The animal was not fed for varying periods depending on the purposes of the investigation but the first period was never less than eighteen hours It was then placed on the observation table and a control record of the activity of the exteriorized loop was made The special procedures essential for each particular study were then carried out and continued observations or records of the activity of the loop were made for as long a period as was essential for the purposes of the investigation The activity was recorded on a kymograph by a double tambour air displacement system

burst into marked activity. This motor response to the ingestion of food occurred in the first loop of jejunum almost as soon as the meal was eaten. From the results of observations made on loops of intestine taken at different distances from the beginning of the jejunum it appeared that the wave of activity initiated by the taking of food passed caudally at the rate of about 1 cm per second. The response to feeding occurred after the food had been given by gastric and duodenal fistulas and was unaffected by section of the vagus nerves in the thorax. It did not occur in completely isolated loops.

COMPARATIVE EFFECTS OF LIQUID AND SOLID MEALS

The comparative effect on intestinal activity of liquid and solid meals was studied by Grindlay and me¹⁰. The purpose of our study was to determine if it would be possible to give an adequate caloric intake of food without producing the marked increase in the intestinal activity which accompanies the ingestion of the standard meal. Water and various liquid meals as bouillon, skim milk, solution of glucose and mixtures of these substances were introduced into the stomach of the animal by tube if the animal would not take the meal voluntarily. The solid meal consisting of cooked meat was always eaten voluntarily. We found that the introduction of a stomach tube caused an increase in intestinal activity for a very short period. The various liquid meals when passed into the stomach by tube or eaten voluntarily caused an increase in intestinal movements of slight amplitude and short duration as compared with the response to the meal of meat. The increased activity that followed the meal of the liquid food rarely lasted longer than an hour while the enhanced movements of the intestine which followed the ingestion of solid food were maintained unabated for many hours.

EFFECT OF PERITONEAL IRRITATION

The mechanism of inhibition of intestinal activity is of interest to the surgeon because inhibition has often been considered the preliminary stage of intestinal paresis and distention. The role of peritoneal irritation in causing inhibition of intestinal activity has been studied by Douglas and me⁶. We produced peritoneal irritation by intraperitoneal injections of a standard irritant solution (compound solution of iodine, Lugol's solution). We

found that the intraperitoneal injection of the standard irritant solution was constantly associated with prolonged arrest of movement in the exteriorized loop of intestine. This arrest of intestinal movements occurred after degenerative section of both vagus nerves or of one splanchnic nerve or after bilateral adrenalectomy but did not occur or was only temporary after degenerative section of both splanchnic nerves. Evidently the arrest of intestinal activity which followed peritoneal irritation in our experiment was in the nature of a reflex inhibition because by reason of the extraperitoneal situation of the loop of intestine the stimulus was delivered to afferents other than those in the loop.

REFLEX INHIBITION OF INTESTINAL ACTIVITY BY DISTENTION OF THE URINARY BLADDER

It is a well known fact that movements of the intestine may be affected by stimuli arising from adjacent organs. With Sævién the effect of distention of the two storage viscera the gall bladder and the urinary bladder was studied. We were surprised to find that intestinal activity was unaffected by distention of the gallbladder. Even with pressures within the gall bladder that were sufficient to cause marked salivation no alteration of the movements of the intestine occurred. On the other

sudden distention of the urinary bladder was followed by a decrease or inhibition of activity in both jejunal and ileal loops of intestine. When the distention of the urinary bladder was produced slowly a decrease in activity occurred in all the loops of ileum but in only about half the loops of jejunum.

EFFECTS OF CATHARTICS

Catharsis increases the rate of elimination from the gastro intestinal tract. The mechanism which is responsible for this increase in rate of passage of gastro intestinal contents is not known. Evidence would indicate that both secretory and motor factors are involved. In association with Oppenheimer¹¹ I have investigated the effect of certain cathartics on the motor activity of the intestine. The drugs employed were selected because of their common use in clinical practice or because of their special pharmacologic action. The animals were not fed for eighteen hours or more before the preliminary observations were made and the drug was administered. After defecation had occurred

the animal was offered the standard meat meal for testing the response to feeding

None of the cathartics studied altered the rate of contraction of any loop of intestine although the amplitude and character were affected. The feeding response was suppressed after the administration of magnesium sulfate. Of the drugs studied, *cas cara sagrada* disturbed the intestinal activity least.

EFFECT OF EMESIS

The activity of the small intestine in vomiting was studied by Oppenheimer and me¹. The emetics were selected on the basis of their special pharmacologic action and included one or more representatives of each of the four pharmacologic groups. The animals were not fed for eighteen hours before administration of the drug. After the resulting nausea or emesis had ceased a standard meat meal was offered and observations were continued on those animals which could be induced to eat.

The results of the study showed that a qualitative difference between jejunal and ileal loops could not be noted. Increased intestinal activity preceded the act of vomiting. Whether this activity was antiperistaltic could not be determined. None of the drugs used altered the rate of contraction of the small intestine although the amplitude and character were affected. The feeding reaction was depressed or absent after emesis due to morphine but it was present after emesis caused by ipecac.

EFFECT OF ANESTHESIA

The anesthetic agent has been considered as one of the factors which may cause intestinal paresis. A study of the effects of some preanesthetic and anesthetic agents in general on intestinal activity was made with Golden. We observed that morphine produced a transitory increase of intestinal activity followed by a depression which was more extensive than that produced by any other substance studied. Spinal anesthesia (procaine hydrochloride) was followed by increased intestinal activity as long as the anesthetic substance was effective. All the other anesthetic agents used were found to have either a depressing effect or no effect on the tone and motility of the loops of intestine studied and no definite stimulation was observed. Recovery of intestinal activity after withdrawal of the anesthetic agent usually occurred with surprising rapidity. Activity of the intestine often

began as the animal was recovering from the anesthetic agent although the amplitude and character of the movements might remain atypical for several hours longer. The response to feeding although sometimes decreased usually occurred at the time the animal would eat spontaneously after withdrawal of the anesthetic agent. The depth of anesthesia appeared to be more significant in producing a decrease in intestinal activity than the length of anesthesia.

EFFECT OF OPERATION

Intestinal paresis and distention have been considered as due to operative trauma. The effect of two types of operative procedures on the activity of the intestine was studied with Wakim. In one series of experiments the abdominal cavity was opened and the intestinal tract explored. In another series the intestine was sectioned and anastomosed, the site of section being proximal or distal to the exteriorized loop in about an equal number of instances. We found that the combination of ether anesthesia and exploratory laparotomy including exposure of most of the intestinal tract for a period of fifteen minutes or more was followed by almost complete cessation of intestinal activity for a minimum of four hours. However, within twenty-four hours the movements of the intestine returned to the preoperative state except that the feeding reaction was not as yet normal.

End-to-side anastomosis of the intestine were followed by complete cessation of intestinal activity for at least twenty-four hours. Intermittent slight rhythmic segmentation movements were noted approximately forty-eight hours after operation and later at the end of seventy-two hours the activity became more marked. In the experiments in which the intestine was sectioned distal to the exteriorized loop the feeding reaction was almost normal on the fourth day after operation but in the instances in which the intestine was sectioned proximal to the loop under observation feeding was followed by inhibition of activity. However, in both types of experiments intestinal activity on the sixth postoperative day was similar in all respects to its preoperative state.

SUMMARY AND CONCLUSIONS

A skin-covered loop of intestine in continuity, with vascular and nerve supply intact, provides a preparation for studying the

motor mechanism of the intestine in some physiologic states and pathologic conditions which it is not possible to study with other methods. The movement of such an exteriorized loop appears to be identical with its activity in its normal position within the abdominal cavity. It seems justifiable to conclude that the results of studies on the activity of the exteriorized loop represent the normal functioning of the motor mechanism of the intestine.

The more significant results of our studies on the activity of the exteriorized loop of intestine which may be of interest to clinicians are as follows:

- 1 The gradient hypothesis of Alvarez is amply corroborated that is the rate and amplitude of the rhythmic intestinal movements decrease progressively from the pylorus to the cecum.

- 2 The rate of movement of any particular loop remains constant and until the present time has not been subject to change.

- 3 Intestinal activity is altered greatly decreased or absent in the fasting state. The longer the fasting period the greater the decrease in activity except for atypical movements. The activity of the ileum is decreased more rapidly and to a greater extent in fasting than that of the jejunum.

- 4 There is an immediate increase of intestinal activity after the ingestion of a meal. This increase of activity passes from the jejunum caudally.

- 5 Solid foods cause more increase of intestinal activity than liquid foods.

- 6 Peritoneal irritation causes inhibition of intestinal activity for varying periods.

- 7 Distention of the gallbladder does not affect intestinal activity.

- 8 Distention of the urinary bladder depresses and inhibits intestinal activity.

- 9 Intestinal activity is greatly decreased altered or abolished for varying periods after anesthesia and operation.

- 10 The standard cathartics alter the amplitude and character of intestinal activity but do not affect the rate of contraction. The feeding response is suppressed after the administration of magnesium sulfate but is unaffected after the administration of cascara sagrada.

11 Increased intestinal activity precedes the act of vomiting but the rate of contraction remains unchanged. The feeding reaction is depressed or absent after emesis due to morphine.

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RESECTION OF THE RIGHT PORTION OF THE COLON*

CHARLES W. MAYO†

This report is based primarily on 135 cases in which resection of the right portion of the colon was performed on my surgical service prior to January 1, 1943. In these cases resection of the right portion of the colon either was the only surgical procedure employed or was performed as part of a multiple stage operation such as partial or complete colectomy. In addition I shall consider thirty one cases in which a palliative ileocolostomy or an exploratory laparotomy was the only surgical procedure employed.

At first I shall consider the group of 135 cases as a whole. Then I shall consider the operative procedure employed and the mortality rate.

In the group of 135 cases there were thirteen postoperative deaths counting all deaths which occurred in the hospital regardless of the length of time after operation or the cause of death—a mortality of 9.6 per cent. A malignant lesion was present in 100 cases; in the remaining thirty five cases the lesion was benign or inflammatory. In the 100 cases in which the lesion was malignant there were nine deaths or a mortality rate of 9 per cent. Resection of the right portion of the colon for benign conditions resulted in four deaths or a mortality rate of 11.4 per cent.

The operative procedures employed in the 135 cases and the resulting mortality are shown in Table 1. The mortality rate in cases in which a palliative ileocolostomy or an exploratory laparotomy was performed is shown in Table 2.

COMMENT

Malignant Lesions—With Lovelace I previously have reviewed all cases of malignant lesions of the cecum and ascending

In this paper the term *right portion of the colon* will be used to designate the cecum and ascending colon including hepatic flexure.

† This paper was prepared before Doctor Mayo's entrance into the armed forces.

colon including the hepatic flexure seen at the Mayo Clinic from 1907 to 1938 inclusive. The operative procedures had been

TABLE 1

OPERATIVE PROCEDURES EMPLOYED IN 135 CASES OF MULTIPLE POLYPOID OR
ULCERATIVE COLITIS WITH RESULTING MORTALITY

Operative Procedure	Pathologic Condition of Large Intestine	Cases	Mortality	
			Number	Percentage
Primary resection of the right portion of the colon with end-to-end ileostomy and closure of the stump of the transverse colon	Malignant	26	3	11.5
	Benign	4	0	
	Total	30	3	10.0
Primary resection of the right portion of the colon with end-to-end ileostomy and transverse colostomy	Malignant	42	1	2.38
	Benign	9	0	
	Total	51	1	1.96
Primary resection of the right portion of the colon with end-to-end ileostomy and closure of the stump of the transverse colon	Malignant	10	1	20.0
	Benign	4	1	25.0
	Total	14	2	14.3
Primary resection followed by primary end-to-end closure of the stomach	Malignant	8	1	12.5
	Benign	7	2	28.6
	Total	15	3	20.0
Primary ileostomy with end-to-end anastomosis of the transverse colon	Malignant	7	1	14.3
	Benign	6	0	
	Total	13	1	7.7
Resection of right portion of the colon of a multiple stage procedure	Malignant	7	2†	28.5
	Benign	5	1	20.0
	Total	12	3	25.0

† The second stage of the operative procedure completed in all the cases.
‡ One patient died of intestinal obstruction some months after the primary operation.

performed by a large number of surgeons consequently the analysis gave a general average picture. This will explain dif

TABLE 2

MORTALITY RATE IN CASES IN WHICH A PALLIATIVE ILEOCOLOSTOMY OR AN EXPLORATORY LAPAROTOMY WAS PERFORMED

Operative Procedure	Cases	Mortality	
		Number	Per Cent
Palliative ileocolostomy for malignant lesions of the right portion of the colon	23	2	8.7
Exploratory laparotomy in cases of extensive involvement	8	0	0

ferences in statistics in this report which is an individual one. It was the result of the aforementioned study, however, which prompted me to change my type of one stage resection and to anastomose the end of the ileum to the cut end of the transverse colon.

Because of the aforementioned study and another one made with Schlicke on one stage resection of the right portion of colon with end to end anastomosis enterostomy as an additional surgical measure in resection of the right portion of the colon has been properly classified as being not an asset but a surgical hazard. In only one instance in the group of cases reported here was a Witzel type of enterostomy performed. In no instance was the Miller Abbott tube used beyond the time of surgical intervention and only in rare instances was intestinal drainage by tube used to prepare the patient for operation. This was because of the rarity of complete obstruction in cases of lesions of the right portion of the colon.

In the last four years 1939, 1940, 1941 and 1942 in only one case of malignant lesion has primary ileocolostomy and secondary resection of the right portion of colon been performed on my service. Also in the last four years no one stage side to side ileotransverse colostomy and inversion of the stumps of the ileum and transverse colon have been performed for a malignant lesion. end to side ileotransverse colostomy and primary resection have been performed in only eight cases but resections with end to end ileotransverse colostomy have been performed in thirty nine cases.

It is my present opinion that one stage resection of the right portion of the colon with primary end to end anastomosis of the ileum to the transverse colon following the technic of suture over rubber covered clamps as described by Schlicke and me is the operation of choice from the standpoints of mortality and morbidity in dealing with malignant lesions requiring resection of the right portion of the colon and that there are very few cases regardless of perforation or size of growth in which this procedure cannot be employed. It often is to be considered in preference to side to-side ileocolostomy even as a palliative procedure when a small amount of metastatic involvement is present in the liver.

Some time ago in order to determine what happens to a hundred patients who come to the Clinic because of malignant lesions of the right portion of the colon a study was made and it was found that nine go home with nothing done that is it is not possible to do anything for them twenty four undergo only palliative procedures (including resection in some cases) and sixty seven undergo resection with the purpose of cure. This gives a resectability rate of 73.6 per cent.¹ The resectability rate in the 166 cases in this report was 81.3 per cent. The resectability rate is calculated as follows: total resections with view to cure — total operations $\times 100$.

Benign or Inflammatory Lesions—In considering surgical resection in cases of nonspecific ileocolitis Judd and I concluded that the average picture when the work of a number of surgeons is concerned reveals that the multiple stage operation as a rule gives the lowest mortality.

Although the number of cases in this series is too small to support or deny this conclusion the group figures are presented. Seventeen patients underwent one stage operations and one of these patients died postoperatively. Of the eighteen patients who underwent multiple stage operations two died.

It is my opinion that greater care must be exercised in selecting a one stage procedure in the presence of a benign inflammatory lesion than is necessary in the presence of a malignant lesion. Certainly in such instances when a one stage procedure is selected the resection should be wide of involved bowel to insure making the anastomosis between colon and ileum in tissue that is free of any inflammation.

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Credit for the enterostomy tube must go to Paul⁴ who in 1891 wrote a paper entitled "A Method of Performing Inguinal Colostomy with Cases" (Fig 377). The purpose of Paul's tube was to drain feces away from the wound to a bottle at the side of the bed and thus avoid soiling (Fig 378). In his paper he

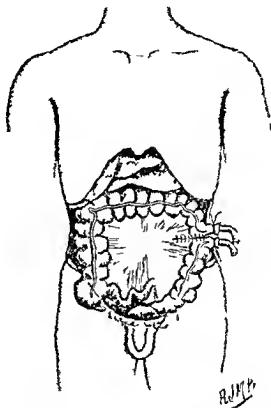


Fig 377—Inguinal colostomy preparation of the colon for the subsequent removal of the spur (Paul E. T. "Colectomy" Brit M J 11136 [May 5] 1895)

said. If it has the disadvantage of using the living intestine too much like a piece of hose pipe, it has the manifest advantage of not interfering with its junction whilst securing an aseptic wound.

Originally Paul and von Mikulicz left the tumor attached extraperitoneally and neither removed much of the mesentery adjacent to the growth. Both surgeons then modified the procedure and removed the growth immediately. Paul in particular

made use of his enterostomy tube to relieve obstruction on extirpation of the growth. Many surgeons are under the erroneous impression that neither Paul nor von Mikulicz removed the malignant lesion at the primary operation.

The next advance in developing extraperitoneal resection for malignant lesions of the colon came from von Mikulicz who never made any claims for priority for the method itself. His contribution had to do with wide excision of the mesentery and lymph nodes about the growth. In 1902 before the 31st German Surgical Congress he discussed and analyzed the results he had obtained in 100 of his own cases and described his two

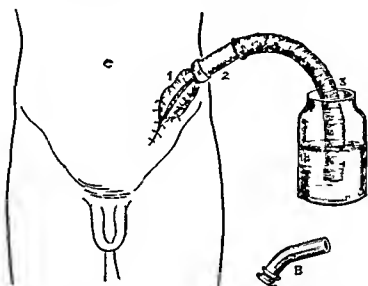


Fig 328.—Inguinal colostomy. 1 upper end of the sigmoid colon is brought out of the wound. 2 a glass tube has been inserted into the sigmoid colon. 3 rubber tube for conveying fecal matter away from the wound. B improved form of glass tube (Paul F T Brit M J, 2 118 [July 18] 1891)

stage resection for tumors of the colon. He expressed himself by saying that other operations were inadequate because extirpation of the lymph nodes of the mesentery had not been included. Accordingly he designed his operation to remove tumor mesentery and lymph nodes as radically as in the single stage resection. At the same time he advocated that the tumor not be allowed to remain on the abdominal wall but that it should be excised at the completion of the first stage and like Paul he advised that the proximal loop of the resulting artificial arms be drained by means of a glass tube fastened in the lumen. The second stage of the operation was performed two to three weeks

after the first stage and was accomplished by applying crushing clamps to the spur thus transferring the artificial anus into a fecal fistula. He did not mention a third stage but said that in cases in which the fistula does not close spontaneously closure can be effected later by suture. This method was similar to that described by Paul.

Von Mikulicz reported sixteen cases in which this method was used. The mortality rate was 12.5 per cent as compared with 47.9 per cent for single stage resection and primary anastomosis.

For whatever the reason but perhaps because of the mechanical difficulties of dealing with the cut ends of the colon surgeons in this country went back to the older method of Paul and Mikulicz and left the growth attached for secondary extirpation. Some called this the Paul operation, some the Mikulicz operation, and others the Paul Mikulicz operation.

In 1909 W. J. Mayo reviewed one hundred cases in which resection of the colon was performed but in referring to what he called the three stage operation of Paul and von Mikulicz he described it as follows. At the first operation the tumor with the mesentery and glands well detached is drawn out of the wound and the proximal and distal loops united by sutures. The part to be excised is then, if possible, drawn through a separate incision in the abdominal wall of just sufficient size to carry it easily and hold it in good position. The peritoneum is united by a few interrupted sutures to the two limbs of the intestine on the inner aspect. If the symptoms of obstruction are severe a small incision is made in the exposed mass proximal to the obstruction and a rubber tube is introduced through which intestinal contents are carried into a receptacle. The tumor with the attached intestine is cut away on the third to fifth day and a heavy clamp applied to the spur on the twelfth to sixteenth day; this bites through about six days later. He reported thirty cases in which resection of the descending colon and sigmoid colon were performed with this technic. Four deaths occurred. In three of six cases in which the extraperitoneal method was employed prior to 1906 the patients were alive more than three years after operation.

It will be noted that the tumor was not removed at the primary operation as described by Paul and von Mikulicz; that the method does correspond with von Mikulicz's wide resection

of lymph nodes and mesentery but not with Paul's method Paul felt that resection of the mesentery and lymph nodes was not important Paul in 1912 asked the question "why should we undertake an extensive excision of the mesentery for removal of glands which in all probability are not infected?"

It is to be noted also that in obstructive lesions after extraperitonealizing the growth W J Mayo made use of tube decompression of the proximal portion of the colon and at the same time guided fecal material from the wound While mention is made of occasional troublesome fistulas resulting after application of the crushing clamp to the spur of the colon it is to be assumed that in most instances spontaneous closure of the stoma resulted

In the same paper, in speaking of resection and primary anastomosis he stated that there are indications when an end to end anastomosis and when a side to side anastomosis should be done It was the opinion that in the presence of a disturbed intestine the side to side anastomosis was preferable

The next paper we wish to consider briefly is that of Sis trunk published in 1928 on 'The Mikulicz Operation for Resection of the Colon Its Advantages and Dangers His objection to what he chose to call the Mikulicz operation (neglecting the fact that Mikulicz in 1902 recommended primary removal of the growth) was that in adherent growths associated with injection of the wall of the bowel and adjacent tissues in large growths associated with infection in growths associated with obstruction and tumors of the sigmoid in obese patients with a short mesentery and a thick abdominal wall infection and peritonitis were not unusual and invasion of the abdominal wall by the malignant lesion was not infrequent

To avoid this he recommended a transverse colostomy as a preliminary procedure to relieve obstruction and set the distal portion of bowel at rest He suggested doing the first and second stages of the original extraperitoneal operation (he called it the Mikulicz operation) about two and a half weeks later in one stage resecting over clamps Later he advised applying spur clamps at both stomas and following the establishment of adequate lumina a double extraperitoneal closure of the two openings in the abdominal wall

In 1930 Rankin described a method of applying what von Mikulicz advised in 1902 that is wide resection of the mesen-

tery and lymph nodes adjacent to the growth. He advocated the principle of combining stages 1 and 2 into a one stage extraperitoneal resection. This technic differed from the original technic in which glass tubes were used by employing an ingenious three bladed clamp conceived from the principle of joining together two Payr clamps.

The technic differed in one other respect namely in the manner of dealing with the proximal segment of colon. Rankin's description of the operation of obstructive resection follows:

The procedure is applicable only to mobile or mobilizable segments of the bowel. The steps of the operation are as follows: (1) Incision over the growth and abdominal exploration (2) mobilization of the growth (3) ligation of the blood supply and dissection of lymph nodes (4) resection of the growth between clamps with the cautery (5) peritonealization and closure of the rent in the mesentery and (6) closure of the abdominal wound around the clamps.

The bowel is left shut off at least sixty hours, sometimes as long as seventy two hours. Then the proximal clamp is opened, the clamp remains on the distal loop until it drops off, usually on the seventh day.

It was Rankin's⁶ opinion that the extraperitoneal operation as he performed it was the choice for all nonobstructing mobilizable growths of the large bowel from the hepatic flexure of the colon to the middle of the sigmoid colon.

Before going on to a description of the method which one of us (C W M) has applied to the majority of cases of resectable growths in the left half of the colon from the splenic flexure (although the method usually applies to growths there also) to the middle third of the sigmoid colon and more occasionally to the lower third of the sigmoid colon, let us pay tribute to those surgeons who initiated the extraperitoneal resection and more particularly to von Mikulicz to whom we and others interested in this field owe a great deal. We recognize that as far as surgery *per se* is concerned little has been added other than certain refinements in technic since he reported his method and reasons for it in 1902.

It is our conviction that while certain credit is due surgeons since those early days of extraperitoneal resection, a majority of it must be laid at the feet of a multitude of research workers

and practical medical men who have contributed so much to cleansing of the colon improved anesthesia and to a better understanding of the prevention of complications by early recognition and early proper treatment of postoperative complications when they do arise

THE PRESENT STUDY

This study is based on a review of 176 consecutive cases of malignant lesions of the left portion of the colon in which a two stage procedure consisting of extraperitoneal resection with temporary catheter colostomy was performed. There were thirteen additional cases in which some type of enterostomy had been performed for the relief of obstruction prior to this procedure (but in which naturally catheter colostomy could be omitted). The cecum was the most common site for such decompression.

The majority of patients were in the sixth and seventh decades of life: sixty six were in the sixth decade and fifty three were in the seventh decade. The oldest patient was eighty three years of age and the youngest was twenty four. Of the 176 patients ninety six were males and seventy were females.

RESULTS

In 108 or 61.3 per cent of the 176 cases operation was performed with the idea of probable cure. There were seven deaths (6.4 per cent) in this group taking into consideration all deaths from all causes following resection: application of clamps or closure of a colonic stoma regardless of the time patients spent in the hospital. There were six deaths (8.8 per cent) in the group of cases in which palliative resection was performed or a total of thirteen deaths (7.4 per cent) in the entire series (Table 1).

Table 1 is self explanatory. Two of the deaths from peritonitis occurred before the discovery and widespread use of the sulfonamides. Both deaths from sudden pulmonary embolism occurred prior to the prophylactic use of dicoumarol which today might prevent such a disaster.

On exploration of the abdomen the surgeon was faced with the necessity of choice of operation. We feel that extraperitoneal resection is the procedure of choice in the treatment of the

majority of lesions situated in the left portion of the colon above the lower part of the sigmoid. When it is used in cases of lesions

TABLE 1

DEATHS IN 103 CASES IN WHICH RESECTION WAS PERFORMED IN AN EFFORT TO EFFECT A CURE

Cause of Death	Death	
	After Resection	After Closure of Colonic Stoma
Pertussis	3	
Pulmonary tuberculosis	1	1
Cardiovascular collapse and acute pulmonary edema	1	
Cerebral hemorrhage	1	
Total	6	1

In this case the stomach was closed with clamp

TABLE 2

SITUATION OF LESION

Situation	Cases	
	Number	Percentage
Upper part of descending colon	12	6.8
Lower part of descending colon	2	1.2
Upper part of sigmoid flexure	26	14.7
Middle portion of sigmoid flexure	61	34.7
Lower part of sigmoid flexure	37	21.0
Rectosigmoid	14	7.9
Descending colon and upper part of sigmoid flexure	1	0.6
Total	176	99.9

in the lower part of the sigmoid and rectosigmoid the operation usually is a palliative procedure and requires that conditions

such as obesity, mobility of the growth and so forth are not contraindications. It can be used with apparent safety in cases in which the patient has suffered from subacute or chronic intestinal obstruction. It also has been employed with no evident additional risk as a palliative procedure in many instances.

It will be noted from Table 2 that most of the growths treated by this method were in the midportion of the sigmoid colon. Obviously in many instances the lesion was situated at the junction of or involved more than one of this arbitrary division.

TECHNIC OF OPERATION

The site of the incision depends on the level of the lesion as established by proctoscopy and roentgenologic examination with a barium enema. Most growths in the sigmoid colon are most easily reached by a low left rectus incision 1 inch (2.5 cm) from the midline with lateral retraction of the muscle. The growths in the descending colon are best approached through an upper left rectus incision about 3 inches (7.5 cm) from the midline with retraction of the muscle medially.

Mobilization of the growth is accomplished by freeing it when necessary from the lateral peritoneal wall or contiguous structures in the peritoneal cavity. A wide V then can be made deeply into the mesentery so as to remove all lymph nodes and yet maintain a good blood supply (Fig. 329). Preservation of the blood supply should be planned so that the remaining edges will remain viable and elevated just above the edge of the skin without undue traction. Those vessels which supply the portion to be removed are ligated. The cut edges of the mesentery are then brought together with two or three interrupted sutures. The anti-mesenteric borders of both barrels then are rotated so that they approximate each other to facilitate the future application of crushing clamps to the spur and eliminate the chance of injury of the blood supply. By this time the change in color of the involved segment of bowel which is to be removed is clearly evident. A three-bladed Ranin clamp is slipped around the two barrels of bowel at the point where there is color demarcation and where there is no undue tension on them. The blades then are applied close to each other. After the various abdominal layers have been closed with chromic catgut around the barrels of bowel tightly enough to admit one finger, the

exteriorized growth is cut off with a cautery above the Rankin clamp

A No. 24 F catheter is next fixed in the proximal barrel next to the Rankin clamp by means of a black silk pursestring suture. Care should be exercised to insert the catheter for a distance of not more than $\frac{1}{4}$ inch (1.25 cm) in the proximal lumb

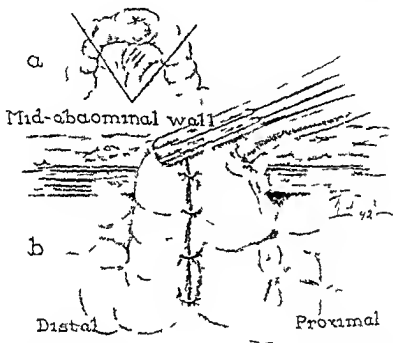


Fig. 39—Extraperitoneal resection with temporary external colostomy. *a* Lateral approach of the sigmoid colon and its mesentery illustrating the extent of the lymphadenectomy in the DeVault segment of tissue that is removed with the lesion. *b* Schematic drawing showing the position of the proximal and distal barrels of the sigmoid colon in the Rankin clamp approximation of both barrels to facilitate future placement of clamp and position of temporary catheter in the proximal barrel.

of the colon. The catheter usually will come free about the sixth or seventh postoperative day and the Rankin clamp usually is found loose about the eighth day after operation.

EXTRAPERITONEAL RESECTION AS A PALLIATIVE PROCEDURE

In Table 3 are listed the instances in which it was felt that the procedure was only palliative. In 108 of 176 cases (61.4 per

cent) this procedure was carried out with a view of cure. This is to be contrasted to the fact that nonpalliative resection was found by Lovelace and one of us (CWM) to be performed in 61 per cent of all cases of malignant lesions of the right portion of the colon in which operation was performed (Table 3).

In fifty four of 176 cases usually because of metastasis to the liver this procedure was considered as definitely palliative. In an additional fourteen cases because of deep palpable involvement of the lymph nodes or on account of perforation and attachment to a neighboring viscus (ileum or bladder) the operation was regarded as probably palliative. Therefore approximately in two of every five cases of extraperitoneal resection the purpose of the operation was not curative. Resection

TABLE 3
OBJECTIVE OF OPERATION IN 176 CASES

Objective	Case	
	Number	Per Cent
Definitely palliative	54	30.6
Probably palliative	14	8.0
Nonpalliative	108	61.4
Total	176	100.0

however was carried out in these cases with a view of increasing the comfort of the patients when otherwise colostomy alone would have sufficed. We do not feel that extraperitoneal resection with temporary catheter colostomy carries an excessive risk in view of the ends to be attained.

Table 4 is self explanatory. It will be noted from comparison with Table 1 that the operative risk is slightly increased in the group in which operation is performed for palliation only but we feel that the additional comfort and longevity which patients derive warrant this risk. With the widespread use of chemotherapy and dicoumarol when indicated we feel that the operative mortality can be lowered still further.

Whenever the growth has caused perforation and is found to

exteriorized growth is cut off with a cautery above the Rankin clamp

A No. 24 F catheter is next fixed in the proximal barrel next to the Rankin clamp by means of a black silk pursestring suture. Care should be exercised to insert the catheter for a distance of not more than $\frac{1}{2}$ inch (1.25 cm) in the proximal limb

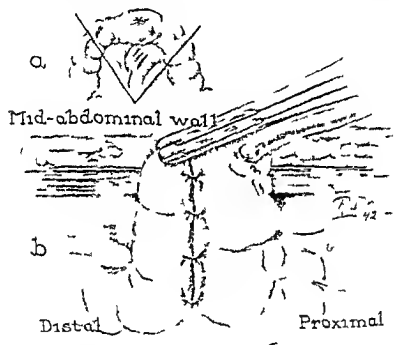


Fig. 39—Extraperitoneal resection of sigmoid colon and its mesentery illustrating the extent of the lymph node dissection included in the distal sigmoid segment of the colon that is removed with the lesion. *b* Schematic drawing showing the position of the proximal and distal barrels of the sigmoid colon in the Rankin clamp, the position of the catheter to facilitate the application of the clamp, and the position of the temporary catheter in the proximal barrel.

of the colon. The catheter usually will come free about the sixth or seventh postoperative day and the Rankin clamp usually is found loose about the eighth day after operation.

EXTRAPERITONEAL RESECTION AS A PALLIATIVE PROCEDURE

In Table 3 are listed the instances in which it was felt that the procedure was only palliative. In 108 of 176 cases (61.4 per

mental resection of the invaded portion with end to end anastomosis over rubber covered clamps

The urinary bladder was closely adherent to the growth usually arising in the lower portion or midportion of the sigmoid in seven cases. Blunt dissection and rather easy separation sufficed in five of these. In another case a small hole was made in freeing the growth but it was recognized and closed promptly. In still another case an enormous perforating lesion in the sigmoid colon had involved a wide region of the wall of the bladder. A palliative segmental resection of the bladder with temporary

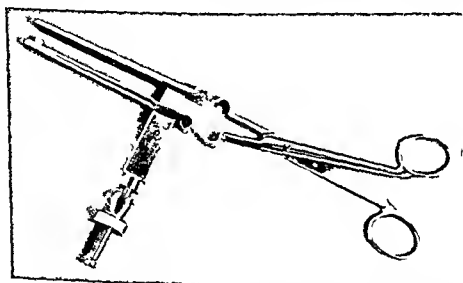


Fig 30—Mayo right angle clamp and holding forceps used for crushing the spur. Tightening of the screw on the right approximates the blades.

cystotomy was performed. The patient enjoyed an uneventful convalescence and was completely comfortable for nearly a year.

Clamps—After extraperitoneal resection of this type the vast majority of patients were able to be out of bed by the ninth or tenth postoperative day. To expedite the handling of the colonic stoma and to maintain a clean wound irrigation of its borders with a solution of sulfanilamide and exposure to lights were carried out twice daily.

Provided that the patient's general condition permitted and all local reaction had subsided the application of clamps to the spur in most cases was carried out on the tenth to the twelfth postoperative day. When the two barrels of bowel had been well approximated at the first stage of the operation application

of clamps was greatly facilitated. Reconnection of the two barrels of bowel by a single set of clamps is possible only by deep accurate application. For many years it was customary to employ two heavy curved Mayo type hemostats for crushing the spur; however, a right angle type of clamp as devised by one of us (C.W.M.) as shown in Figure 330 was found to be more efficient in most cases for crushing a thick low septum. With this instrument it is possible to avoid multiple applications of clamps in the majority of cases. For a short type of spur the older heavy curved hemostat is to be preferred.

In Table 6 are listed those cases in which clamps were applied. It is worthy of note that in most cases a single application of the spur crushing clamp has sufficed in the past few years.

TABLE 6

NUMBER OF APPLICATIONS OF CLAMPS TO THE SPUR IN INDIVIDUAL CASES	
Number of Applications	Cases
1	7
2	59
3	16
4	4
5	4
6	1
Total	159

In several cases in which palliative operation is employed a special clamp is employed. A special clamp is employed in the case of a distal anastomosis.

From the figures in Table 6 it will be noted that one application sufficed in almost half (47.1 per cent) of 159 cases in which clamps were applied; that in 132 (83 per cent) only two applications were required. The incidence of multiple applications has declined markedly in the past few years.

To facilitate this procedure and to eliminate undue discomfort while it is being done, the intravenous administration of 5 to 10 cc. of a 2.5 per cent solution of pentothal sodium has been found to be of benefit. Discomfort of any degree is present only for a day or so. Most patients feel well enough to be up and about within twenty-four hours and can indulge in the usual convalescent activities.

With the Mayo type of right angle clamp, daily tightening of the screw is required to maintain the blades in close approximation. Other than this, no special care except ordinary cleanliness is required. In most cases the septum between the barrels

is crushed within seven to eight days allowing the clamp to fall off

At this point the surgeon has three alternatives. For some previously debilitated and elderly patients the wisest course of action is to allow them to go home. In the majority of cases closures can be considered.

Closure may occur spontaneously or it may be secured by surgical means.

Spontaneous Closure—Selected patients may be allowed to go home without further surgical procedures. In approximately fifteen cases in this group a closure occurred spontaneously.

Surgical Closure—Before the colonic stoma is closed certain criteria must be fulfilled: (1) The spur must be properly crushed to allow adequate communication between the proximal and distal barrels of bowel. (2) Most of the fecal content must be eliminated by the rectum. This is directly related to the success in obliteration of the spur, as in 1. (3) The patient's general condition must be favorable enough to warrant such a procedure.

In about half of the cases in which surgical closure is to be performed examination will disclose a variable degree of induration at the point where the clamps have been applied. When this situation exists, it is important to wait a week or ten days to allow the low grade inflammatory reaction to subside. We feel that the application of diathermy to this region will facilitate subsidence of inflammatory reaction. If the spur has not been divided sufficiently another application of clamps is necessary. This usually is sufficient for functional reconnection of the barrels.

Through and through irrigation of the distal limb of bowel for one day prior to closure and a nonresidue solid diet for one or two days are the only preoperative requirements.

We believe that extraperitoneal closure of the colonic stoma is not only safe but also entirely adequate for a good functional result. Wide dissection and identification of each successive layer usually are not necessary. Under pentothal anesthesia the colon at the site of the stoma first must be separated from the abdominal wall surrounding it. Only large vessels should be ligated; oozing later can be controlled best by a small iodoform pack.

After the edges of the two barrels have been freed the mu-

cosa is inverted with a running suture of no. 00 catgut (on a Dulax needle) by using the baseball stitch. A few interrupted catgut sutures in the serosa are helpful for reinforcement. The anterior fascia is then brought over the repaired colonic stoma and united with three or four interrupted chromic catgut sutures. About 45 to 60 grams of powdered sulfamilamide is sprinkled in the subcutaneous space. A small plain gauze or iodoform strip is left in for forty-eight hours to stop superficial oozing. Two or three heavy Zytel strands are inserted through the skin, subcutaneous tissue and fascia, but these are left untied until the pack is removed two days after operation. Since closure of a colonic stoma in effect is the suturing of a potentially infected wound, we feel as Moorhead did about many war wounds, that so-called primo secondary suturing is the treatment of choice.

Postoperative care is essentially similar to that used after resection, with some modification. A glycerin suppository and a rectal tube are inserted every four to six hours for three or four days to facilitate the passage of flatus. A nonresidue solid diet for five or six days, followed by a low residue diet for two or three weeks, will aid in the protection of the anastomosis. Exposure of the wound to lights helps to insure healing. The patient is out of bed by the fourth or fifth day and is usually out of the hospital by the tenth day. We do not feel that slight leakage from this site necessitates further hospitalization, since in the vast majority of cases closure will be complete within a short time after the patient has gone home.

Persistent drainage of fecal matter from the repaired colonic stoma usually is due to two causes: (1) partial or incomplete obliteration of the spur (this will necessitate a further application of clamps); (2) recurrence of the primary malignant lesion. It is rare in our experience for the lesion to recur at the site of the stoma without evidence of recurrence elsewhere. In selected cases in which the recurrence appears to be local, resection may be attempted. In the majority of cases, however, further operation usually is contraindicated and palliative treatment with roentgen rays or radium should be employed. Even when only palliative treatment is possible, we feel that means of promoting closure in selected cases are desirable for reasons of morale and comfort.

SUMMARY

This article summarizes the experience of one of us (C W M) during a ten year period (1933 to 1943 inclusive) in 176 consecutive cases in which extraperitoneal resection has been performed at the Clinic

It is important again to emphasize that recent acute or subacute intestinal obstruction from neoplasms in the left portion of the colon can be safely and effectively handled by this method since the temporary insertion of a catheter affords prompt decompression Diversion of the fecal current in this manner for about a week allows ample time for healing of the wound around the site of the stoma Healing is further facilitated by the local irrigations with solution of sulfanilamide

With recent refinements in preoperative and postoperative care as previously outlined the operative mortality (7.4 per cent for the entire series) can be kept at a low level The risk of this procedure is slightly greater (about 2 per cent) when it is performed only as a palliative procedure

While there is some risk involved in applying clamps and performing surgical closure it has proved to be minimal Care for application of clamps and adequate obliteration of the colonic spur are essential to successful closure We believe that this procedure should be entirely extraperitoneal

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INTRAPERITONEAL CHEMOTHERAPY

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and

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The local implantation of certain of the sulfonamide drugs either in the soft tissues or in the pleural or peritoneal cavities of the body has gained widespread patronage among the surgeons of this country in the past two years. Despite the decrying voices of a few early dissenters the intraperitoneal use of sulfanilamide and sulfathiazole has proved to be relatively harmless and an effective means of combating peritoneal infection. It has been repeatedly stressed by writers in this field that a sulfonamide compound administered intraperitoneally is an adjunct to good surgery and should in no wise lessen strict observance of sound surgical principles. There is no uniformity of opinion regarding the best suited type of sulfonamide compound for intraperitoneal use nor regarding dosage. Sulfanilamide used first with gratifying results is still adhered to by many. Recently the trend has been toward the use of sulfathiazole or sulfadiazine. Sulfapyridine is little used within the abdomen and there is experimental evidence that its use here is contraindicated.⁴ We feel that some understanding of the manner in which the sulfonamide compounds act and some familiarity with the literature on intraperitoneal chemotherapy are essential to the proper use of the drug within the abdomen.

MODE OF ACTION

Lockwood in 1938 and McIntosh and Whitby in 1939 suggested that the bacteriostatic action of sulfanilamide is due to an interference with bacterial metabolism. This interference was thought to be an inactivation of some bacterial enzyme. Wildes in 1940 hypothesized that disinfectants and other bacteriostatic substances prevent the growth of bacteria by interfering with an essential metabolite (a substance essential to the growth of the organism). At his suggestion Woods undertook

study of this problem and identified para aminobenzoic acid as the essential metabolite. Wood's experiments produced strong evidence that sulfanilamide and para aminobenzoic acid (whose chemical structures are closely related) compete with each other for the bacterial enzyme concerned in the further utilization of para aminobenzoic acid in the bacterial cell. The outcome of this competition depends on the relative proportions of the two substances present. If para aminobenzoic acid is present in greater quantity than sulfanilamide bacterial growth will continue; if sulfanilamide is present in greater quantity bacterial growth will cease.

The bacteriostatic action of all the sulfonamide drugs as well as sulfanilamide is brought about in this same manner. The bacteriostatic effect of each of the drugs depends on its capacity to counteract para aminobenzoic acid.^{44 45} This capacity varies with the different sulfonamide compounds.

REVIEW OF LITERATURE

It has been fairly well shown both experimentally and clinically that the sulfonamide compounds if used properly in wounds do not interfere with healing nor administered intraperitoneally do they as a rule evoke such inflammatory reactions that adhesions are formed. The early reports of the diminished tensile strength of wounds in dogs that were given sulfanilamide orally have been refuted by the studies of Taffel and Harvey Zintel and others.⁴¹ Jacoby, Medawar and Willmer studied the toxicity of the sulfonamide compounds on the cells in living tissue cultures and found the inhibitory effects to be negligible. Some⁴⁶ have expressed their feeling that sulfanilamide stimulates fibroblastic growth. Osgood said that sulfathiazole is less toxic to human living cells than sulfanilamide. Jensen, Johnsrud and Nelson first reported the use of sulfanilamide directly in wounds. They used the drug locally in treating thirty nine compound fractures without the occurrence of a primary infection. According to Key and Burford the prophylactic dusting of sulfanilamide and sulfathiazole has been a factor in reducing infections in clean wounds. They and others⁴⁷ have pointed out that the powdered or crystalline drug should be dusted thinly and evenly over the wound surfaces. Clumping of the drug in the wound forms a virtual dead space which predisposes to drainage. The Subcommittee on Surgical Infec

tions of the National Research Council has recommended the use of only that amount of drug necessary for light dusting of the wound. This amount should not exceed 1 gm of drug for each 10 square inches (65 square centimeters) of wound surface.

Throckmorton investigated the peritoneal cellular response to the implantation of the sulfonamide compounds. He found that they stimulated the peritoneum to a nonspecific cellular response. For example, the response of the mononuclear phagocytes to sulfanilamide was very mild, to sulfathiazole rather marked, while sulfapyridine suppressed the number of mononuclear phagocytes. Furthermore, sulfapyridine frequently produced masses of permanent adhesions. Throckmorton expressed the opinion that sulfadiazine, while less irritating than sulfapyridine, is more irritating than sulfathiazole. Reports^{1, 3, 40} have appeared proclaiming the harmful effects of intraperitoneally administered sulfonamide compounds. Sutton reported a case in which adhesions developed at the site of implantation of sulfathiazole for peritonitis and operation had to be performed a second time for intestinal obstruction. However, Laird and Stavern did not find any harmful effects following use of sulfanilamide and sulfathiazole. Jackson and Collier stated that there is no evidence that the local application of sulfanilamide injures peritoneal surfaces and they expressed the belief that chemotherapy may well reduce formation of adhesions due to pyogenic infection. Certainly it seems that the few reactions one encounters after implantation of the sulfonamide compounds are of little consequence compared with those that will doubtless occur if peritonitis is allowed to develop.

The mortality rate of dogs in which peritonitis has been experimentally produced has been lessened by intraperitoneal chemotherapy. Rosenberg and Wall carried on the first experiments of this nature. Eleven of twenty peritonitic rats receiving sulfanilamide intraperitoneally lived indefinitely, while twenty not receiving chemotherapy died. Laufman and Wilson found that powdered sulfanilamide introduced into the peritoneal cavity of rats four hours before they were infected with *Escherichia coli* and *Streptococcus faecalis* was of more benefit than if introduced after infection was present. Pearl and Ricles introduced suspensions of sulfathiazole into the abdomens of rats along with pure culture of *Escherichia coli*. Rats that received the suspension were protected, while others which did

not receive it, died Epps Lev and Howard found that a suspension of sulfathiazole was more effective than sulfanilamide in protecting dogs from experimentally produced peritonitis They expressed the belief that for intraperitoneal use a suspension of the drug is superior to the powdered or crystalline drug The powdered material they found is rapidly walled off in the peritoneal cavity by omentum and is ultimately dependent on absorption and systemic concentration for its local effect

Concentrations of sulfanilamide from seventy five to one hundred times higher than systemic concentrations may be obtained by the local use of sulfanilamide either in the soft tissues or in body cavities according to Mueller and Thompson They determined the concentration of sulfanilamide in the drainage fluid of a patient who had an appendiceal abscess and who had received sulfanilamide intraperitoneally at operation High levels varying from 300 to 800 mg per 100 cc of drainage fluid were obtained for more than forty hours after operation Mueller and Thompson stated that no other form of the drug could produce such high concentration in the peritoneal fluid Peak blood levels after intraperitoneal implantation of sulfanilamide were reached in ten to eighteen hours and averaged 7 mg per 100 cc of blood They concluded that the drug is not absorbed into the system in toxic amounts

Jackson and Collier implanting 5 gm of sulfanilamide intraperitoneally found that maximal concentrations of nearly 10 mg per 100 cc of blood were reached in about two hours and that at twenty four hours levels of less than 2 mg per 100 cc of blood were found Nine of sixty two patients who received sulfanilamide intraperitoneally became jaundiced However each of these received in addition to the intraperitoneal drug supplementary chemotherapy orally or parenterally Jackson and Collier investigated the question of whether intraperitoneal administration of the drug was more likely to lead to hepatitis than administration by other routes They found that the concentration of sulfanilamide in blood from the portal vein of a dog half an hour after implantation of the drug was higher than that in blood drawn from the jugular vein at the same time The difference however was not great

Ambrose and Griswold found that sulfadiazine after intraperitoneal use was absorbed and excreted more slowly than either sulfanilamide or sulfathiazole Because of this slower rate

of absorption they and others³⁴ expressed the belief that it is the drug of choice for intraperitoneal use

That chemotherapy is an efficient weapon in combating peritoneal infection is best attested by the lowered mortality rates in peritonitis since its introduction I add Botsford and Curnen Ravdin Rhoads and Lockwood and others³⁵ have shown the values of systemically administered sulfonamide compounds in reducing the mortality rate of primary peritonitis of children and of peritonitis of appendiceal origin

In September 1940 Dees first reported the intraperitoneal use of sulfanilamide in twenty five cases of appendiceal perforation Only one patient died Mueller said that at the Roosevelt Hospital in New York crystalline sulfanilamide was used intraperitoneally as early as January 1940 in treatment of a critically ill patient The results were dramatic The routine intraperitoneal use of sulfanilamide in the presence of peritonitis was soon established McChes reported a series of 407 cases of appendiceal perforation in which sulfanilamide was used intraperitoneally The mortality rate in this series of cases was 62 per cent Thompson Brabson and Walker reported no deaths from acute suppurative appendicitis during 1940 when they used sulfanilamide intraperitoneally Previously the average mortality rate for all cases of appendicitis with and without perforation had been 77 per cent Kinney and Griswold reported the satisfactory intraperitoneal use of sulfanilamide Deaver expressed the belief that sulfanilamide is not harmful when used intraperitoneally and that it may be beneficial in cases of early peritonitis In treating children less than fourteen years of age he used not more than 1 to 7 gm intra peritoneally and 1 to 7 gm in the wound

Mueller and Thompson suggested that the dose of sulfanilamide (in grams) for intraperitoneal and local use should be 8 per cent of the pounds of body weight in cases in which drainage is used and 6 per cent in cases in which it is not used Two thirds of the total dose is placed within the abdomen and a third in the wound The total dose should never exceed 18 gm Mueller and Thompson expressed the opinion that systemic concentration of the drug is of only secondary importance unless infection is present outside the peritoneal cavity Gardner has used a suspension of sulfapyridine intraperitoneally in nineteen cases of peritonitis without untoward results

Tashiro and others found that for each gram of sulfanilamide placed intra abdominally a concentration of 1 mg per 100 cc of blood could be expected. Hudson and Smith have used 10 to 15 gm of sulfanilamide intraperitoneally in the treatment of peritonitis and peritoneal contamination since October 1940. Their mortality rate dropped from 55.5 per cent (before October 1940) to 8.3 per cent (from October 1940 to October 1941). Recently Smyth reported on the use of sulfanilamide in 178 cases of acute appendicitis with no deaths. Some of the patients received sulfanilamide not intraperitoneally, but by hypodermoclysis. Smyth expressed the belief that sulfanilamide is the drug of choice since in his opinion it is more effective than other sulfonamide compounds against the organisms most frequently involved in peritonitis of appendiceal origin.

Toxic reactions from intraperitoneal sulfonamide therapy are unusual unless supplementary oral or parenteral chemotherapy is carried out too soon following the intraperitoneal implantation. Jackson and Collier found that 14.5 per cent of their patients became jaundiced. However each of these patients in addition to the sulfanilamide placed in the abdomen received the drug by other routes immediately subsequent to operation. Lesses and Starr reported one case in which severe anemia and leukopenia developed after the intraperitoneal use of sulfanilamide. To prevent urinary suppression which may follow intraperitoneal chemotherapy a daily urinary output of at least 1200 cc should be maintained.

From this general review of the literature certain facts are established and certain questions are raised. The sulfonamide drugs are relatively harmless locally and intraperitoneally if proper choice and use of them are made. Opinions differ regarding the drug of choice and the dosage. Neither sulfapyridine nor sulfadiazine is the drug of choice. The sulfonamide drugs probably have played a great part in lowering the mortality rates in clinical and experimentally produced peritonitis. The intraperitoneal use of the drug is rarely attended by toxic reactions. Certain questions are brought to mind. Does the drug deposited at one point within the abdomen diffuse through the peritoneal fluid to establish high concentrations at other points? Or is the drug walled off? Should supplementary chemotherapy be carried out subsequent to the intraperitoneal use of a sulfona-

mide compound? It was hoped that the observations described in the following paragraphs might shed some light on these questions

CONCENTRATIONS IN THE PERITONEAL FLUID AND URINARY EXCRETION OF SULFANILAMIDE AND SULFATHIAZOLE

Sixteen patients all of whom had pelvic operations through low midline incisions received intraperitoneal chemotherapy. In twelve cases sulfathiazole was the drug used. In four sulfanilamide was used. The crystalline drug was used in all cases in doses of 5 or 10 gm. The crystals were deposited either by dumping or by spreading in either the upper part of the abdomen (over the omentum or in the region of the gallbladder) or in the pelvis proper. In each of these cases except two a No. 10 urethral catheter was brought out through the lower angle of the abdominal wound, the tip of the catheter being placed in the pelvis. In two cases the tips were fixed in the cul de sac with plain catgut stitches and the catheters brought out through the vaginal vault. At intervals following the intraperitoneal deposition of the drug peritoneal fluid was aspirated through the catheters and determinations of the sulfonamide concentrations were made. Between the aspirations which were done every two hours the catheters were clamped off so that the sulfonamide concentration of each sample represented the concentration in the pelvic peritoneal fluid at a particular time. In addition to the sulfonamide concentrations of the peritoneal fluid determinations of concentration in the blood were made at certain intervals and the total sulfonamide excretion in the urine was followed daily whenever possible. In those cases in which sulfathiazole was used the urine excreted during the first five days after administration of the drug was examined to determine the presence of crystals.

In most instances it was impossible to aspirate peritoneal fluid after about twenty four to thirty six hours probably because the perforations in the catheter tips became occluded by omentum. In some instances it was impossible to aspirate any fluid and in some fluid could be aspirated only at irregular intervals.

High concentrations of sulfanilamide ranging from 770 to 1330 mg per 100 cc of fluid were obtained in the peritoneal fluid aspirated from the site of deposit of the drug. These high concentrations were maintained for more than twenty four

hours (curve *a*, Fig 331) In one case in which the sulfanilamide was deposited in the region of the gallbladder the concentrations in the peritoneal fluid from the lower part of the abdomen approximated the concentrations of sulfanilamide in

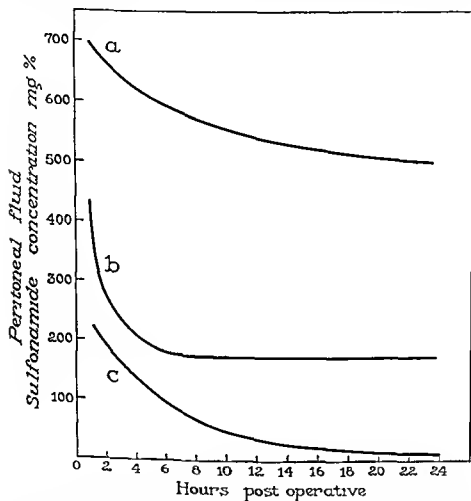


Fig 331—Changes of concentration of sulfonamide compounds in peritoneal fluid after their implantation in the peritoneal cavity *a* Approximate concentrations of sulfanilamide in peritoneal fluid aspirated from the site of deposit of 10 gm of the drug *b* approximate concentrations of sulfathiazole in peritoneal fluid aspirated from the site of deposit of 10 gm of the drug after the initial drop there was no more decrease during the period studied *c* approximate concentrations of sulfathiazole in peritoneal fluid aspirated from a point 6 inches (15 cm) away from the site of deposit of the drug

the blood This suggested that the drug in the upper part of the abdomen had become walled off (or that the catheter had become walled off) and that such concentrations as were obtained in the peritoneal fluid of the lower part of the abdomen

were dependent on the concentrations in the blood. This was further borne out by results obtained with sulfathiazole.

The concentrations of sulfathiazole in the peritoneal fluid drawn from the region of deposit of the drug were not as high as those of sulfanilamide (curve *b* Fig 331). The maximal solubility of sulfathiazole in serum at 37° C is reported to be 184 mg % per 100 cc. The fact that some concentrations were higher than 180 mg per 100 cc probably was due to the aspiration of undissolved crystals of sulfathiazole. Curve *c* of Figure 331 represents the concentrations of sulfathiazole in peritoneal fluid drawn from a point about 6 inches (15 cm) distant from the site of deposit of the drug. In those cases in which sulfathiazole was deposited further away from the catheter (about the gall bladder) the concentrations in the peritoneal fluid were approximately the same as the concentrations in the blood. These concentrations ranged between 7 and 10 mg per 100 cc. We consider this further evidence that the drug does not diffuse throughout the peritoneal fluid but becomes walled off in a few hours.

Peak concentrations of 10 to 25 mg of sulfanilamide and 4 to 10 mg of sulfathiazole per 100 cc of blood were obtained four to eight hours after intraperitoneal deposit of 10 gm of the drug. After twenty-four hours the concentrations of sulfanilamide ranged from 4 to 8 mg per 100 cc of blood while the concentrations of sulfathiazole were 1 to 3 mg per 100 cc.

When all of the sulfanilamide was placed in one region of the peritoneal cavity, approximately 35 per cent of it was excreted during the twenty-four hours after operation. In those cases in which sulfanilamide was spread evenly over the peritoneal surfaces, between 50 and 60 per cent of the drug was excreted in twenty-four hours. One week after operation practically all of the sulfanilamide which had been placed in one region of the peritoneal cavity had been excreted in the urine. When the drug was spread about, excretion of the total amount was usually complete by the third or fourth postoperative day. Sulfathiazole is excreted more slowly than sulfanilamide (Fig 332). Approximately 12 per cent of sulfathiazole was excreted during the first twenty-four hours after the material had been deposited in one region of the peritoneal cavity. Under such circumstances some of the material can be detected in the urine as late as fourteen

days after its deposit in the peritoneal cavity. When the sulfathiazole is spread thinly over the peritoneal surfaces as much as 30 to 50 per cent may be excreted in the first twenty four hours.

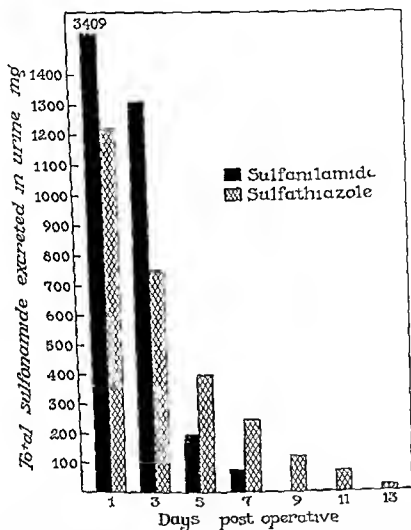


Fig. 332—A comparison of the average rates of excretion of sulfanilamide and sulfathiazole in the urine of two groups of patients, one of which received 10 gm of sulfanilamide intraperitoneally and the other 10 gm of sulfathiazole intraperitoneally.

Thus from this brief study one can conclude that sulfathiazole administered intraperitoneally has a more prolonged local action than sulfanilamide; that with both drugs only a relatively local effect is obtained in high concentrations. There is evidence to suggest furthermore, that the lower concentrations obtained

in more distant regions of the peritoneal cavity are secondary to the concentration of the drug in the blood

DRUG OF CHOICE METHOD OF INTRAPERITONEAL ADMINISTRATION DOSE

There is no unity of opinion regarding the type of sulfonamide compound best suited for intraperitoneal use. However the drug of choice should possess certain essential prerequisites. As postulated by Throckmorton it should be polyvalent that is active against a variety of organisms it must be innocuous to the peritoneum it should exert a prolonged bacteriostatic effect and it should stimulate the natural defense mechanism thus augmenting the attenuating effect of the drug on the invading bacteria. Throckmorton expressed the opinion in which we concur that sulfathiazole of all the types of sulfonamide compounds at present available best meets these requirements.

Recently Green and Parkin have stressed the fallacy of the widely held view that the different drugs are specific against certain bacterial species. They pointed out that the drug most active against one organism is normally the most active against all organisms. The bacteriostatic effect of each drug as mentioned previously depends on its capacity to counteract para aminobenzoic acid and this capacity varies considerably with the different drugs. Green and Parkin found that sulfathiazole counteracts about fifty times as much para aminobenzoic acid as sulfanilamide. This is in accord with the work of Wood who found that the bacteriostatic potency of sulfathiazole is fifty times that of sulfanilamide while sulfadiazine and sulfapyridine have only twenty times the potency of sulfanilamide. Of the compounds now available sulfathiazole appears to have the greatest capacity to act against the pathogens which most commonly cause peritonitis.

We do not feel that the deposition of crystals of the drug in one spot within the peritoneal cavity is inferior to the methods of spreading the drug about as much as possible or of insufflating the powdered drug over the peritoneal surfaces unless there is general widespread infection present. It has been our experience that if the drug is spread its absorption and excretion take place much more rapidly than if it is concentrated in one spot and that thus the spreading of the drug cuts short its prolonged bacteriostatic effect. By dumping the drug at a de-

sired point one obtains high local concentrations at that point for a longer period than by spreading it. We have used this dumping method of administering the drug intraperitoneally in most of our cases. In none of these cases have there been complications that would suggest the development of localized inflammation or abscess or the undue formation of adhesions. In instances of general peritonitis however it is desirable to apply the drug over as much of the peritoneal surface as possible if this can be done without breaking down protective and walling off adhesions. In such cases of peritonitis we believe that subsequent systemic chemotherapy should not be started earlier than twenty-four to forty-eight hours after sulfanilamide has been used intraperitoneally and perhaps three to four days after sulfathiazole has been used.

We have seldom used more than 10 gm. of sulfanilamide or sulfathiazole intraperitoneally. For prophylaxis in the usual case of a clean abdominal incision we ordinarily use 5 gm. Reports have appeared of the intraperitoneal use of as much as 25 gm. of the drug. While we have never used such large doses we feel that if a high urinary output is maintained they can be handled by the system without untoward effect.

Crystals of a sulfonamide compound have proved somewhat superior in our experience to the powdered or the microcrystalline forms of the drug. The powder and microcrystals have a tendency to clump forming a rather hard mass. We have not had any experience with the use of suspensions of a sulfonamide compound. It is possible that such suspensions may diffuse more readily throughout the peritoneal cavity than powder or crystals. If this is true the use of suspensions of a sulfonamide compound might be indicated in cases of established and spreading peritonitis. Probably however because of protective adhesions one could obtain more even distribution throughout the peritoneal cavity by raising the level of the sulfonamide compound in the blood by the intravenous or the subcutaneous route.

PROPHYLACTIC INTRAPERITONEAL USE OF SULFONAMIDE COMPOUNDS

In an attempt to determine the value of intraperitoneal chemotherapy as a prophylactic measure we adopted the routine of placing either 5 or 10 gm. of crystals of a sulfonamide compound within the abdomens of all patients having major ab-

dominal operations who were cared for on our service. From April 1941 to December 31 1942 inclusive we have so treated 791 patients. In addition to those patients having abdominal operations we have had 218 patients undergoing vaginal hysterectomy who received intraperitoneal chemotherapy prophylactically. In all we have used either sulfanilamide or sulfathiazole intraperitoneally in more than 1 000 cases. Sulfanilamide was used in approximately two thirds of the cases and sulfathiazole in a third. A detailed study of these cases is being made at present and will be presented sometime in the near future.

There have been no major untoward reactions to the intraperitoneal implantation of crystals of the sulfonamide compounds which we have used and it is our opinion that intraperitoneal chemotherapy such as we have employed is not contra-indicated in so called clean cases. Minor reactions have occurred; it is true. In one case in which sulfanilamide was given intraperitoneally after appendectomy anemia and leukopenia developed on the second postoperative day but these cleared up. In two cases in which sulfanilamide was given intraperitoneally at operation and orally after operation mild icterus developed but this cleared up after administration of the drug by mouth was stopped. In several cases in which sulfathiazole was given intraperitoneally reactions developed. These reactions usually appearing about the tenth to fifteenth day after operation occurred for the most part in cases in which in addition to intraperitoneal administration of sulfathiazole the drug was given subsequently by mouth. They were characterized by elevation of temperature nausea and the development of a pruritic nodosal erythematous eruption. In two cases temporary oliguria and renal pain developed and crystals of sulfathiazole were observed on examination of the urine. These reactions have quickly subsided when administration of the drug by mouth was discontinued and an adequate urinary output was effected. In three cases although no chemotherapy was given after sulfathiazole was placed in the abdomen similar reactions with fever and erythematous eruptions developed. It was noted that on the two days prior to the fever the intake of fluid was rather low and the urinary output had dropped considerably below the desired level. We feel that a urinary output of at least 1 200 cc a day should be maintained for at

least two weeks after operation. We also believe that when sulfathiazole is used intraperitoneally and subsequent chemotherapy is indicated some type of sulfonamide compound other than sulfathiazole should be used. Recently we have been using sulfadiazine for additional chemotherapy subsequent to the intraperitoneal use of sulfathiazole.

While we have found little to contraindicate the prophylactic intraperitoneal use of sulfonamide compounds we cannot say that their use in the usual clean case has produced amazingly beneficial results. However in those cases in which peritoneal contamination has possibly occurred especially in operations on the colon the prophylactic use of the sulfonamide compounds has served a good purpose. Ravdin, Loelwood and Rhoads have used sulfanilamide prophylactically both systemically and intraperitoneally in fifty-four cases in which operations on the colon were performed. There were no deaths from peritonitis although two patients died of other causes. Peritonitis is the bete noire of colonic surgery and most of the deaths after operations on the colon result from it. Ravdin and his associates said that peritonitis has become an infrequent occurrence in this clinic since the introduction of the prophylactic use of sulfanilamide. Our experience echoes theirs. During 1942, on our service we have performed 126 procedures involving the colon on 110 patients with three hospital deaths a hospital mortality rate of 2.7 per cent (Table 1). This group represents cases in which adequate preoperative preparation was carried out and does not include procedures done in an emergency shortly after the patient was admitted. It cannot be said that the prophylactic use of the sulfonamides alone accounted for this low mortality rate. Certainly the preoperative and postoperative use of the Miller Abbott tube and recently the use of sulfasuxidine have been valuable aids in the handling of these patients. Nonetheless the incidence of peritonitis after operations on the colon has been greatly reduced owing to a large extent to systemic and intraperitoneal chemotherapy so that the risk per patient now is approximately a fourth that of five years ago.

Even more dramatic has been the effect of the sulfonamide compounds on the mortality rate of peritonitis secondary to perforative appendicitis. In 1937 we first began to use sulfanilamide in the form of subcutaneously administered prontosil for

TABLE 1

COLONIC OPERATIONS 126 PROCEDURES INVOLVING 110 PATIENTS

	Number	Deaths	Cause of Death
Right hemicolectomy Onstage peritonitis Tostag operation	16 1	0 0	
Extrapertoneal resection	23	1	Reactated chronic ulcerative colitis pelvic abscess beginning general peritonitis early pneumonia
Combined abdominal peritonitis section Onstage operation	26	2	(Both patients resections for extensive perforating lesions) 1 Necropsy not done. Clinical cause of death was bronchopneumonia peritonitis and paralytic ileus 2 Patient with old infarct of left atrial bulbar hydrothorax with atelectasis of left lobes cerebral infarct
Tostag operation	3	0	
Psternoresection	7	0	
Anterior resection	2	0	
Subtotal colectomy (diffuse polyps)	2	0	
Total colectomy (3 tags) (chronic ulcerative colitis)	2	0	
Colectomy	24	0	
Closure of colostoma	18	0	
Transcolonoscopic removal of polyps	2	0	
Total	126	3	

Extrapertoneal resection (after the Mikulicz method) for lesions of the transverse descending and sigmoid colon

† In addition to the combined abdominal operation hysterectomy was carried out at the same time because of a perforating adenocarcinoma of the lower part of the sigmoid

‡ A mortality rate of 2.7 per cent

such patients in what have since proved to be minimal doses. There was no appreciable lowering of the mortality rate although our clinical impression was that the drug was beneficial. By consulting Table 2 one can see that it was not until 1940 when the dose administered subcutaneously was adequate in light of our present knowledge that any marked fall of mortality rate was obtained. We first used sulfanilamide intraperitoneally in 1940 but only in a few cases. In 1941 and 1942 practically all patients received sulfanilamide or sulfathiazole intraperitoneally and this was followed by additional subcu

TABLE 2

PERFORATIVE APPENDICITIS (SPREADING PERITONITIS OR ABSCESS)

	Total	Died	Mortality Rate Per Cent
1936	45	9	20.0
1937	34	5	14
1938	49		14.3
1939	38	7	18.4
1940	59	3	5.1
1941	39	2	5.1
1942	34	0	0
1936-1939 No or inadequate chemotherapy	166	78	16.9
1940-1942 Adequate chemotherapy	132	5	3.8

taneous or intravenous administration of the drug maintaining adequate concentration in the blood for at least one week. With the employment of adequate chemotherapy in 1940 and since the mortality rate in a consecutive series of 132 cases in which operation has been performed at the Mayo Clinic for perforative appendicitis with peritonitis or abscess has been 3.8 per cent. In a similar series of 166 consecutive cases in which operation was performed in the four year period prior to 1940 the mortality rate was 16.9 per cent. It would seem that the outstanding factor in this reduction of mortality rate accom

panying perforative appendicitis was the use of adequate doses of sulfonamide compounds.

Sulfanilamide has been used intraperitoneally in perforative appendicitis more often than sulfathiazole but no marked difference has been noted in their relative efficacy. However, because sulfathiazole remains in the peritoneal cavity longer is a better stimulant of local cellular response and is a polyvalent antibacterial agent it seems likely that it will be accepted as the drug of choice. Following implantation in the peritoneal cavity of 5 to 10 gm. of either sulfanilamide or sulfathiazole supplemental intravenous or subcutaneous chemotherapy should not be started until after the second or third postoperative day. Such supplemental treatment may be continued however for five days or for longer if necessary.

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GRAMICIDIN AND PENICILLIN

WALLACE E. HERRELL

The problem of combating infection has always been of great interest to clinician and surgeon alike. To date perhaps the greatest contribution to the treatment of infections has been sulfanilamide, the parent compound or one of its derivatives. Until recently, however, these agents were even at best only bacteriostatic *in vivo*. The search has continued for substances which are bactericidal and yet at the same time possess sufficiently low toxicity for tissue to render their use practicable.

The theory of bacterial antagonism has long been known. Recently, however, interest in this phenomenon has revived and as a result many so-called antibiotic agents have been studied. In 1939 Dubos reported on a natural antibacterial substance which is elaborated by the anaerobic spore-bearing soil bacterium *Bacillus brevis*. To this crude substance which he isolated was given the name gramicidin, since the material was bactericidal under certain conditions for gram-positive pathogenic bacteria. It was later found that the crude material (now known as tyrothricin) contained two substances, gramicidin and tyrocidine. Considerable experimental work has been done on gramicidin and tyrocidine and some clinical reports have appeared dealing with the use of crude gramicidin in the treatment of infections.

Fleming of London in 1929 described penicillin, the antibacterial agent produced by the mold *Penicillium notatum*. For eleven years little was heard of this rather remarkable substance. In 1940 a group of Oxford investigators (Chain, Florey, and others) reported their work with penicillin. According to them, the substance was active in inhibiting the growth of streptococci, staphylococci, and anaerobic organisms associated with gas gangrene. The material was obviously not related to any chemotherapeutic substance in use at that time. The work of Dubos stimulated this further work on a natural substance elaborated by the mold. Abraham and others in 1941 presented

in greater detail the studies by the Oxford investigators and included reports on the first trials in the treatment of disease of man

Although gramicidin and penicillin are related substances it should be emphasized that differences in their selective antibacterial activity and probably also in their mode of action and toxic effect are well marked. Physically and chemically the substances are different. Both gramicidin and penicillin possess in general relatively low toxicity. Although gramicidin and penicillin are bacteriolytic under certain circumstances gramicidin as has been reported previously is hemolytic whereas penicillin does not produce hemolysis of erythrocytes. Since the two substances differ to some degree our experiences with the use of these materials will be presented separately.

GRAMICIDIN

In 1941 Heilman and I⁸ presented studies which confirmed in part the work of Dubos with regard to the antibacterial activity of gramicidin. These bacterial studies were made with the aid of the tissue culture method. We⁸ further pointed out that gramicidin was relatively without any serious toxic effects for tissue with the exception of its ability to produce hemolysis of erythrocytes in the blood of experimental animals and also in human blood. Attempts to remove the hemolytic property of gramicidin resulted in loss of its bacteriostatic effect. Further it has been shown⁶ that gramicidin behaves like an anionic detergent. More recently the antibacterial and cytotoxic activity of gramicidin have been compared with a few of the commonly used antiseptics.^{9, 10} Gramicidin produces less toxicity for tissue than the other germicides studied with the exception of penicillin. Two quaternary ammonium compounds phemerol and zephiran which are synthetic detergents compare favorably with gramicidin. However a cationic detergent such as phemerol will neutralize the antibacterial activity of gramicidin.

From these data it seemed that gramicidin should prove effective in the treatment of clinical infections due to organisms known to be susceptible to gramicidin. The fact that gramicidin should not be administered if it would come in contact with the blood stream must be considered however. It can be used locally in the treatment of wounds and for instillation into the

pleural cavity sinuses or urinary bladder As a result of studies in which purified gramicidin and tyrocidine were used it was found that gramicidin is a little more cytotoxic than tyrocidine Tyrocidine aids in keeping gramicidin in suspension and also inhibits growth of certain gram negative bacteria on which gramicidin has little effect Hclman and I however have felt that it was not practical to fractionate the crude gramicidin (tyrothricin) for clinical use All of the clinical material herein reported therefore, consists of cases in which crude gramicidin (tyrothricin) was used rather than purified gramicidin or tyrocidine

Clinical Use of Tyrothricin

In this paper the results of treatment with crude gramicidin in 142 cases are summarized The case histories are not presented in detail but the entire group is summarized in Tables 1 2 and 3 The material used clinically in the 142 cases was a suspension of tyrothricin (crude gramicidin) in triple distilled water The resulting suspension contained 500 micrograms per cubic centimeter and was prepared by dissolving 0.5 gm. of the tyrothricin in 20 cc. of alcohol and to this was added 20 cc. of glycerin (USP) The resulting solution was made up to a liter with distilled water Stock solutions of crude gramicidin may be prepared in the form of the alcohol glycerin solution The necessary amount of gramicidin to yield 0.5 gm. per liter then may be added in the usual way It seems unwise to permit the material to stay in the water phase for more than a week to ten days The suspension described is isotonic and is entirely safe for general use locally

The clinical results in 142 cases have been grouped into three general classes (1) good or excellent (2) fairly good and (3) poor (Table 1) The fact that the results could be considered poor in approximately a fifth of the entire group is not due entirely to ineffectiveness of gramicidin in the infections treated In a few cases the infections were caused by organisms which were resistant but in many the amount of gramicidin used would be considered inadequate at present At any rate nearly four fifths of the results could be considered good excellent or fairly good

The results in the entire series have also been evaluated according to the type of lesion in which the material was used

(Table 2) The material was used on infected ulcers and wounds in ninety three cases with poor results in only seventeen cases

TABLE 1

RESULTS OF CLINICAL USE OF TYROTHRIN (CRUDE GRAMICIDIN) IN 147 CASES

Result	Cases	
	Number	Percentage
Good	5	33
Fairly good	16	5
Poor	31	77
Total	142	100

(18 per cent) Many of these failures were not due to absence of antibacterial activity on the part of gramicidin but to inadequate treatment. It is my general impression that clinical

TABLE 2

RESULTS OF CLINICAL USE OF TYROTHRIN (CRUDE GRAMICIDIN) IN 142 CASES ACCORDING TO TYPE OF LESION

Infection	Cases	Results					
		Good		Fairly Good		Poor	
		Cases	Percentage	Cases	Percentage	Cases	Percentage
Ulcers and wound	93	4	51	29	31	17	18
Sinus	21	13	62	2	10	6	28
Bone	19	9	48	5	26	5	26
Bleeder and pleura	15	9	60	13	4	77	

Multiple types of lesions were present in a few cases

use of tyrothrin has given the most favorable results in this type of case

One of the ulcers of the type usually encountered in this group is shown in Figure 333 *a*. This chronic ulcer of the leg had been present for one year. A strain of hemolytic streptococcus was obtained on culture from the infected region. Following

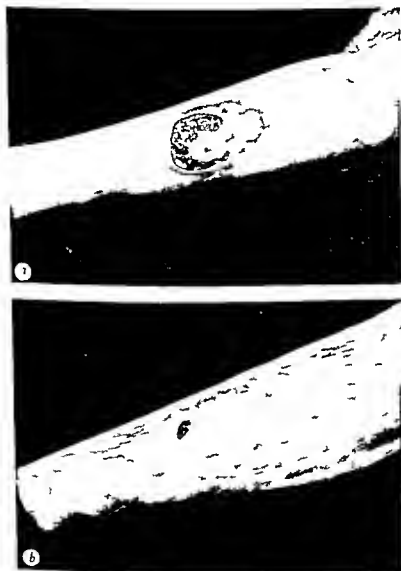


Fig. 333—Typical ulcer *a* before treatment with gramicin *b* fourteen days after treatment was begun

local treatment with tyrothricin the cultures became negative within a few days. Complete healing of the ulcer took place without the necessity of using skin grafts (Fig. 333 *b*). The material has proved useful in many instances in preparing ulcer

(Table 2) The material was used on infected ulcers and wounds in ninety three cases with poor results in only seventeen cases

TABLE 1

RESULTS OF CLINICAL USE OF TYROTHRICIN (CRUDE GRAMICIDIN) IN 142 CASES

Results	Cases	
	Number	Per Cent
Good or Excellent	5	53
Fairly good	36	25
Poor	31	22
Total	142	100

(18 per cent) Many of these failures were not due to absence of antibacterial activity on the part of gramicidin but to inadequate treatment. It is my general impression that clinical

TABLE

RESULTS OF CLINICAL USE OF TYROTHRICIN (CRUDE GRAMICIDIN) IN 142 CASES ACCORDING TO TYPE OF LESION

Infection	Cases	Result					
		Good or Excellent		Fairly Good		Poor	
		Cases	Per Cent	Cases	Per Cent	Cases	Per Cent
Ulcers and wounds	93	47	51	9	31	11	18
Sinus	21	13	62		10	6	28
Bone	19	9	48	5	26	5	26
Bladder and pleura	15	9	60	2	13	4	

Multiple types of lesion present in 7 cases

use of tyrothricin has given the most favorable results in this type of case

placement technic Nasal sprays of the material or instillations are not satisfactory

In cases in which infection of bone was associated with wounds and ulcers the number of good or excellent results was somewhat less than in the two groups previously mentioned. In only 48 per cent of these cases could the results be considered good and in the other 52 per cent they were only fair or poor. Since most of these infections are caused by the *Staphylococcus aureus* these observations tend to confirm experimental evidence that *Staphylococcus aureus* is somewhat

TABLE 3

RESULTS OF CLINICAL USE OF TYROTHRICIN (CRUDE GRAMICIDIN) IN 142 CASES
ACCORDING TO TYPE OF ORGANISM PRESENT

Organism	Cases	Results					
		Good or Excellent		Fairly Good		Poor	
		Cases	Per Cent	Cases	Per Cent	Cases	Per Cent
<i>Streptococcus pyogenes</i>	42	27	64	10	24	5	12
<i>Staphylococcus aureus</i>	42	19	45	11	26	12	29
Miscellaneous organisms	44	23	52	9	21	12	27
No organism found	10	21	50	13	31	8	19
No cultures made	32						

One hundred twenty eight organisms present in 110 cases in which cultures were made

resistant to gramicidin. In a small group of cases in which the infection occurred in the pleura or urinary bladder fairly good or excellent results were obtained in nine of the fifteen cases (60 per cent). The results were fairly good in 13 per cent and poor in 27 per cent.

The results in the 142 cases have also been analyzed with regard to the type of organism isolated in these cases (Table 3). It is interesting that the best results were obtained in those infections due to the *Streptococcus pyogenes*. In thirty seven (88 per cent) of forty two cases fairly good or excellent results

were obtained and in five failures occurred. This also is consistent with the observations made in the laboratory studies with this material. In 45 per cent of the forty-two cases in which *Staphylococcus aureus* was the organism of infection, fairly good results were recorded in 75 per cent, whereas failures occurred in twelve which is a little more than twice the number of failures experienced in cases in which *Streptococcus pyogenes* was the organism of infection.

In the group of cases in Table 3 in which miscellaneous organisms were present, a large variety including *Streptococcus faecalis* and *Streptococcus salivarius*, pneumococci, as well as a number of gram-negative organisms were encountered. It is interesting that the results were fairly comparable with those in the group just mentioned, namely the infections owing to *Staphylococcus aureus*. Good or excellent results were obtained in approximately half, fairly good in about a third, and failures in approximately another fourth. Clinical experience in a similar group of cases at the Clinic has been reported previously, and the data herein presented are about the same as those previously reported. Fairly good, good, or excellent results occurred in approximately three-fourths of the cases, while poor results occurred in a fourth. I have already emphasized that in a certain number of cases in which results were poor, the quantity of material used often was not adequate.

Crude gramicidin is quite safe for use locally, intrapleurally by instillation into other cavities such as sinuses and ureters. It possesses little if any cytotoxic activity in general. Antibacterial amounts of the material are much less than the amounts which would be required to produce a toxic effect even under experimental conditions. As mentioned before, it is less toxic than any of the commonly used germicides. Its only superior at the moment, as far as lack of toxicity is concerned, is penicillin. Gramicidin should not be used where it may come in contact with the blood stream.

PENICILLIN

During the past two years Heilmann and I have investigated the antibacterial activity of penicillin.⁷ By means of the culture method described in previous articles, it has been possible to confirm to a large degree the data presented by British investigators. As in the case of gramicidin, penicillin

been compared with other germicides commonly used. Penicillin has been found superior to any of the germicides tested because of its low toxicity. Penicillin is bacteriolytic for certain organisms. It does not behave like gramicidin so far as detergent activity is concerned. While gramicidin is stable and relatively insoluble in most solvents, penicillin is highly soluble and is easily destroyed by alterations in the pH of surrounding media. It is hygroscopic, it is sensitive to oxidizing agents but less sensitive to reducing agents. Heat, primary alcohols and heavy metals alter penicillin considerably. Because of these properties penicillin is not as easy to prepare or to handle as gramicidin. Products of breakdown of tissue or para-aminobenzoic acid do not inhibit the action of penicillin.

The primary advantage of penicillin, besides its antibacterial activity, is that it may be administered subcutaneously and may, if it is pyrogen free, be administered intramuscularly or intravenously without evidence of toxicity. Penicillin is antibacterial for the *Staphylococcus aureus*, *Streptococcus pyogenes*, *Diplococcus pneumoniae*, *Neisseria gonorrhoeae* and *Neisseria intracellularis*. *Actinomyces bovis* is also susceptible to the action of penicillin. Gramicidin is effective against *Streptococcus faecalis* but penicillin is not. Penicillin is not effective against *Mycobacterium tuberculosis* or against common or gram-negative organisms. It is illogical therefore to use penicillin in the treatment of infections caused by the resistant organisms mentioned. Its greatest usefulness should be in the treatment of severe and systemic infections due to the pathogens inhibited by its action. Because penicillin appears rapidly in the urine, it should prove valuable in infections of the urinary tract caused by susceptible organisms.

Penicillin may be used locally in the treatment of infections due to susceptible pathogens. However, its instability and the difficulty in its preparation suggest that its widespread use is not practicable at the moment. Many other antibacterial substances are easily available for this type of treatment. Gramicidin and the synthetic quaternary ammonium compounds are examples. Penicillin may be administered subcutaneously without difficulty. However, in the treatment of severe infections, particularly in the presence of bacteremia, I am of the opinion that the continuous or nearly continuous *intravenous* use of pyrogen free penicillin is the method of choice. The material

rapidly disappears from the blood stream into the surrounding tissues and is rather rapidly excreted in the urine. The continuous intravenous administration therefore insures a more uniform and continuous contact between the antibacterial agent and the bacteria invading the blood stream than any other method of administration. Periodic intravenous injections of relatively large amounts of penicillin followed by an interval during which the amount of the material in the blood is almost negligible may do much to encourage the development of so called penicillin resistant or penicillin fast pathogens.

For the treatment of moderately severe or severe infections 30 000 to 40 000 Oxford units per twenty four hours is in my opinion an adequate amount of penicillin. Half of the twenty four hour dose is dissolved in 1 liter of physiologic solution of sodium chloride. If for any reason the administration of physiologic solution of sodium chloride is undesirable penicillin may be administered in a 5 per cent solution of glucose in triple distilled water. Initially between 100 and 200 cc of the material is administered intravenously at a fairly rapid rate. Following this the rate of injection is regulated to between 30 and 40 drops per minute. The second liter containing penicillin may be attached to the continuous intravenous system eight to ten hours later. Repeated venipunctures may be avoided by allowing the solution of glucose to drip in slowly during the interval in which penicillin is not being administered. A simple arm splint is applied to keep the arm in position. This is tolerated well by the patient and renders the continuous intravenous administration possible and not uncomfortable. When pyrogen free penicillin has been used no toxic reactions have been observed. The solution containing penicillin is made up immediately before use. There is no evidence of loss of potency of the material which is left in the closed intravenous system and is administered in the manner described.

We have used penicillin recently in the treatment of ten patients suffering from moderately severe infections. Eight of these infections were due to the *Staphylococcus aureus*. The diagnosis, the organism of infection and the amount of penicillin used as well as the clinical results are summarized in Table 4. One of these cases (Case 10) was previously reported in some detail.¹¹ The patient suffered from overwhelming sepsis associated with facial and orbital cellulitis together with septicemia.

TABLE 4
CLINICAL RESULTS FOLLOWING PENICILLIN THERAPY

Case	Diagnosis	Infecting Organism	Blood Culture	Days Treated	Total Mg	Penicillin Oxford Units	Administration	Results
2	Extensive facial cellulitis	Staphylococcus aureus	+	12	1113	196 000	Intravenous	Recovery
3	Acute postoperative pyelonephritis	Staphylococcus aureus	0	7	850	200 000	Intravenous	Recovery
4	Extensive cellulitis of mouth and tongue	Nonhemolytic streptococci	0	4	320	64 000	Intravenous	Recovery
5	Infected postoperative wound	Staphylococcus aureus	0	5	440	88 000	Intravenous	Recovery
6	Severe facial and nasal cellulitis	Staphylococcus aureus	0	6	561	132 000	Intravenous	Recovery
7	Subacute bacterial endocarditis	Green producing streptococci	+	6	640	128 000	Intravenous	Failure
8	Chronic ulcer osteomyelitis	Staphylococcus aureus	0	10	16 8	2 100	Local	Good
9	Chronic ulcer	Staphylococcus aureus	0	7	16 8	2 100	Local	Good
10†	Facial and orbital cellulitis	Staphylococcus aureus	+	9	1160	160 000	Intravenous	Recovery
11	Multiple encapsulated abscesses	Staphylococcus aureus	+		34	4 200	Subcutaneous	Recovery

0 = negative + = positive
† Previously reported

Case II is another example of an overwhelming infection associated with staphylococcal septicemia

Case II—The patient treated with penicillin administered intravenously was a child four years of age suffering from extensive



Fig 334 (Case 2)—a and b Patient at beginning of treatment



Fig 335 (Case II)—a Patient ninety-six hours after beginning treatment with penicillin b Nine days after treatment as noted

facial and orbital cellulitis complicated by septicemia due to a virulent strain of hemolytic *Staphylococcus aureus*. On culture there were 25 colonies of the organism per cubic centimeter of blood. Pneumonia was present in the right upper lobe of the lung. Thirty

six hours after initiation of treatment with penicillin blood cultures were sterile and remained so throughout the patient's recovery. This patient is shown at the beginning of treatment in Figure 334 *a* and *b*, ninety six hours afterward in Figure 335 *a*, and nine days after treatment was instituted in Figure 335 *b*. It seems likely that penicillin was responsible for this rather striking result.

The absence of any evidence of toxicity resulting from the use of penicillin is gratifying. There has been no evidence of toxic effect on the blood elements of the patients treated or of renal irritation. Hyperpyrexia has not occurred in any case in which pyrogen free penicillin has been used. In most instances, temperatures of patients treated with penicillin have a tendency to decline gradually rather than rapidly as often happens on use of the sulfonamide compounds.

SUMMARY

Experimental and clinical experiences with gramicidin and penicillin have been presented. Gramicidin is a highly effective antibacterial substance for most gram positive pathogens. It is considerably less toxic for tissue than most germicides in use at present. Gramicidin behaves like an anionic detergent and is hemolytic. For this reason its clinical use is restricted to local application and to implanting it into infected cavities. A review of 142 cases in which crude gramicidin has been used indicates that approximately four fifths of the results could be considered good or better. Therapeutic failures occurred in approximately a fifth of these cases. The results vary somewhat depending on the type of lesion and the organism identified.

Experimental and clinical studies indicate that penicillin is also a highly effective antibacterial agent against a variety of pathogenic organisms. Penicillin is even less toxic for tissues than gramicidin. Penicillin does not behave as a detergent like substance and is not hemolytic. Penicillin may be administered locally, subcutaneously, intramuscularly or intravenously without evidence of toxicity. Penicillin should prove of great value in the treatment of severe infections. In using penicillin the principles concerned with its somewhat selective antibacterial activity should be adhered to strictly. Neither gramicidin nor penicillin can be substituted for sound medical and surgical judgment so essential in the management of bacterial infections.

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RESULTS OF USE OF FASCIAL AND NONFASCIAL SUTURES IN HERNIAL REPAIR

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and

JAMES C MASSON

The surgeon of today will utilize the same basic principles in any operative procedure he may select for the treatment of indirect inguinal hernia namely high ligation and excision of the sac with reconstruction of the hernial defect, but his choice of suture material for approximation of tissue is not so pre determined. In direct inguinal hernia, disposition of the sac is of minor importance and strengthening of the floor of the inguinal canal is the all important consideration. In postoperative ventral hernia umbilical hernia and epigastric hernia some type of plastic overlapping of available tissues is a basic requirement. Autogenetic fascia foreign suture material or a combination of autogenetic fascia and foreign suture material each has ardent supporters who present substantial evidence to uphold their positions.

HISTORICAL APPROACH

Before the turn of the present century Halsted suggested that delicacy in manipulation of tissue and the leaving behind of a minimal amount of the least irritating foreign material were essential aids to healing of wounds and with these factors in mind he advocated use of silk suture material. In spite of lack of wide acceptance at that time he continued to employ silk and in recent years there has been a general revival of its use. Utilization of silk with commendable results has been reported by Whipple Parsons Swinton and Sanderson and others. They found that silk promoted strong healing with minimal tissue reaction and that its use was accompanied by a low rate of occurrence of wound infection.

There were others however who objected to the use of silk wire or other nonabsorbable suture in repair of hernia. Among

the first of these was Coley. On his service these materials were associated with a high incidence of formation of sinuses and of separation of the tissues of wounds. He advised use of catgut or kangaroo tendon instead. Irdman expressed the belief that catgut was the most nearly universally used material and that it had stood the test of time.

In 1901 McArthur proposed that narrow strips be cut from the aponeurosis of the external oblique muscle that these strips be left attached to the pubic spine and that they be used as suture material for uniting the structures that were defective in cases of inguinal hernia. Later experimental studies of Gallie and LeMesurier⁴ demonstrated the principle which now governs plastic operations on aponeurosis, fascia and muscle. They found that when these structures were sutured together with ordinary material the adjacent areolar tissue produced union by a rather delicate scar which would not withstand much increased tension. They suggested the use of fascia lata as a suture material and found that whether utilized as a free or as a pedunculated transplant it continued to live unchanged in the presence of an adequate supply of lymph. Since the work of these pioneers was done, use of fascial transplants in repair of hernia has been the subject of numerous discussions, favorable and unfavorable. During the last fifteen years fascia lata has been used extensively at the Clinic in repair of difficult hernias and a desire to evaluate the method prompted this study.

TECHNICAL CONSIDERATIONS

Several technical points which we have found valuable in repair of hernias with autogenetic fascia might be mentioned. The number of fascial sutures used in any given hernia depends first on the length of the individual sutures and second on the size of the hernia. As a rule, sutures from 20 to 30 cm. in length can be obtained from the thigh and two such sutures are sufficient for a satisfactory operation on the inguinal canal. For large postoperative hernias from 130 to 140 cm. of autogenetic fascial material should be used. Our present tendency is to use more fascial material in the repair of a hernia than we used previously. Not the type of suture material alone but the way it is utilized is significant. In using autogenetic fascia important points are as follows: to use a sufficient amount of suture material for avoidance of tension; to keep the suture material buried

as much as possible, to anchor sutures frequently by passing them through other sutures to remove as much fatty tissue as possible and to effect thorough hemostasis. In postoperative ventral hernias and umbilical hernias where overlapping of tissues is indicated we make the primary closure of the peritoneal cavity with a continuous suture of number 1 chromic catgut and then reinforce with strips of fascia lata. We have had no experience with the many tailed flaps of fascia which Gallie³ has recommended in preference to fascial sutures for repair of large hernias.

Fascia for sutures is easily and successfully obtained by use of the Masson fascia stripper⁸ and only a single small incision is required. Patients have not experienced difficulty with thighs from which fascia has been taken either immediately or after an interval of several years. There is practically no danger of muscle hernia developing if the fascia is removed from the outer aspect of the thigh and even if a muscle hernia should develop it would be of no consequence. Two such hernias have occurred in 844 cases. As much fascia as is needed can be obtained; the fascia of both thighs can be made available with no inconvenience in draping the patient and we think it advisable to remove some from both thighs rather than a large amount from one. For most hernias however enough fascia can be obtained by introducing the fascia stripper once into one thigh removing a strip of fascia lata from $\frac{3}{4}$ to 1 inch (about 2 to 2.5 cm) wide and then dividing it into multiple sutures about $\frac{1}{8}$ inch (0.3 cm) wide.

Burying as much of the fascia as possible which has been mentioned affords maximal contact between the fascial sutures and the aponeurotic and muscular portions of the abdominal wall. On completing the operation very little of the fascial sutures should show. Anchoring of the fascial sutures by passing them through previous sutures which also has been mentioned obviates undue tension. Some of the sutures should run parallel to the long axis of the wound and others should run at right angles to it; they should not be put in under tension. If tension is necessary catgut sutures should be used also to hold the tissues together until the fascial sutures unite with the tissues of the abdominal wall and thus are enabled to retain their vitality.

When the size of the hernial opening renders it impossible to overlap the edges of a wound the defect can be darned in as a

seamstress darns a stocking. In most cases however enough tissue even if it is thin scar tissue can be saved to make a double breasted type of closure and this can be strengthened by multiple fascial sutures running in both directions. Silkworm sutures occasionally are used to prevent tension during healing. Soft rubber drains are desirable when large raw surfaces are produced. Such surfaces make for collection of serum especially in cases of huge postoperative ventral hernia.

TYPES OF HERNIA SUITABLE FOR FASCIAL REPAIR

Broadly speaking the types of hernia selected for fascial repair as presented by Gallie and LeMesurier⁴ and with which we agree are (1) direct inguinal hernia (2) combination of direct and indirect inguinal hernia (3) large scrotal hernia in which the canal has lost its obliquity and the internal ring lies approximately behind the external ring (4) all forms of recurrent hernia and (5) all ventral hernias including umbilical and epigastric types. In addition certain individual factors influence the decision as to the type of suture material to select that is the size of the hernia previous surgical attempts obesity and the muscular and tendinous development of the patient.

COMPARISON OF RESULTS OF USE OF FASCIAL AND NON FASCIAL SUTURES IN HERNIAL REPAIR IN 2 298 PATIENTS

The evaluation of autogenetic fascia was made for this study by comparing the results obtained with its use and those obtained with use of foreign suture material in repair of hernias of 2 298 patients encountered at the Clinic. The operations were performed by fourteen surgeons from January 1 1937 to December 31 1941 inclusive. Thus a year or longer was allowed for postoperative observation. The hernias were limited to those of inguinal femoral ventral umbilical and epigastric types as shown in Table I.

Factors Pertinent to Recurrence of the Hernia

The factors of age obesity wearing of a truss strangulation of hernia previous hernial repair infection of the wound and other postoperative complications were considered with regard to their possible pertinence to recurrence of the hernia. The follow up inquiry was carried out by letter except in those cases wherein the patient returned for examination. It is recog

nized that the latter method is the more accurate but as many of the patients lived at great distances from Rochester to use this method was not possible in some cases. There were twenty-two cases of ventral hernia associated with colostomy in all of which repair was by chromic catgut, because of the apparent

TABLE 1

RECURRENCE RATES ACCORDING TO TYPE OF HERNIA AND TYPE OF SUTURE USED

Type of Hernia and Suture Used	Cases	Recurrences	
		Number	Per Cent
Inguinal direct	203	5	2.5
Fascia			
Nonfascia			
	122	4	3.3
	81	1	1.2
Inguinal indirect	858	33	3.8
Fascia			
Nonfascia			
	253	16	6.3
	605	17	2.8
Inguinal multiple	386	33	8.5
Fascia			
Nonfascia			
	230	21	9.1
	156	12	7.7
Femoral	102	3	2.9
Fascia			
Nonfascia			
	7	0	—
	95	3	3.2
Ventral	554	58	10.5
Fascia			
Nonfascia			
	208	24	11.5
	346	34	9.8
Umbilical	158	13	8.2
Fascia			
Nonfascia			
	17	1	5.9
	141	12	8.5
Epigastric	37	2	5.4
Fascia			
Nonfascia			
	7	0	—
	30	2	6.7
Total	2298	147	6.4
Fascia			
Nonfascia			
	844	66	7.8
	1454	81	5.6

The bilateral hernias direct and indirect are included in this group.

factor of gross infection these are not included in the series of 2,298.

Sex and Age of Patients—Among the patients who demonstrated all the types of hernias reviewed there was a preponderance of males except among patients with femoral and

ventral hernias (Table 2) Males constituted approximately 84 per cent of the group in which fascia was used but made up only somewhat more than 69 per cent of the individuals whose hernias were repaired with foreign suture material. Females on the other hand comprised only about 17 per cent of the patients whose hernias were repaired with living fascia and slightly higher than 31 per cent of those in whose operations foreign suture material was used. The patients with the larger and more difficult hernias usually were males. Sixty seven male patients were subjected to associated orchidectomy at the same time that the inguinal canal was repaired with two recurrences (3 per cent). We feel that in operating on elderly patients with large hernias this is a justifiable procedure especially because it is advisable to get these patients out of bed at an early date and it definitely lessens the chance of recurrence.

It is relatively easy to obliterate the inguinal canal of the female and the success attending attempts at its obliteration was demonstrated by the presence of only one recurrence among eighty nine inguinal repairs made on female patients. Repair of postoperative ventral hernias also is generally easier among females than among males because the abdominal wall of the female is more lax and is muscularly less well developed. There were nine recurrences among 139 female patients whose hernias were repaired by fascial suture or a rate of recurrence of more than 6 per cent. Among 453 females whose hernias were repaired with foreign suture material there were twenty four recurrences or essentially the same rate of recurrence (more than 5 per cent) for a smaller and technically easier type of hernia to repair.

Among male patients the percentage of recurrence was larger in cases in which fascia lata was used than in cases in which foreign suture material was employed. This can be explained however by the facts that many of these hernias were huge that previous attempts at surgical repair had been made in many cases and that some form of truss had been used for many months by many of the patients. In 705 operations on males autogenetic fascia was used with fifty seven recurrences (8 per cent) whereas in 1 001 cases in which foreign suture material was used there were fifty seven recurrences (about 6 per cent).

It must be considered when comparing results obtained with

male and female patients that males are much more likely to return to heavy work sooner than female patients and are less likely to be cautious against overexercising

In Figure 336 is represented the frequency of recurrence in each decade of life. The chart emphasizes the progressive increase in rate of recurrence as the patients advance in age. Among patients in the fifth decade of life the rate of recurrence was about 7 per cent whether autogenetic fascia or foreign

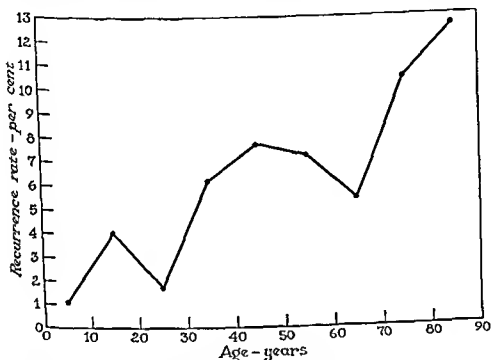


Fig 336—Rate of recurrence according to age irrespective of suture material used

suture material was used whereas there were scarcely any recurrences among patients who were less than ten years of age

The group of patients whose hernias were repaired with fascia presented enhanced risk of recurrence because they were of advanced age. The group contained individuals of whom nearly 82 per cent were more than forty years of age as compared with the group of patients whose hernias were repaired with foreign suture material among whom only about 62 per cent were of an age more than forty years. From the clinical standpoint it was noted that many of the elderly patients appeared to be suffering from malnutrition with its associated low reserves

of protein and vitamins. The stimulating effect of adequate intake of vitamin C and protein on the fibroblastic activity on which healing of wounds partly depends has been demonstrated repeatedly by several observers and probably would be worth considering before undertaking surgical repair in cases such as have just been mentioned.

Wearing of a Truss—Of the 963 patients who were more than forty years of age 377 or 34 per cent were wearers of trusses. Among those whose hernias were repaired with autogenetic fascia wearers of trusses were of more frequent occurrence (nearly 31 per cent) than among those in whose operations foreign sutures were employed (about 15 per cent). One of us (Masson) believes that wearing of a truss causes devitalization of tissues and increases the difficulties of surgical repair and healing.

Obesity—Patients whose hernias were repaired with foreign suture material were as a rule much less obese than patients in whose operations autogenetic fascial sutures were employed. This may however be a reflection on the factor of age. Of the patients whose hernias were repaired with fascia nearly 42 per cent weighed more than 170 pounds (77 kg) whereas of the patients in whose operations foreign suture material was used the weights of only about 27 per cent exceeded that figure. It is generally accepted that excess fat interferes with approximation of tissue and with healing of the fascial and muscular layers. Obese patients also are assumed to present an increased hazard with reference to postoperative complications. Support for these beliefs seems to be furnished by the fact that among the patients whose hernias recurred 43 per cent weighed more than 170 pounds (77 kg) as compared with 30 per cent who weighed more than this among all patients subjected to operation. This again may be a reflection of the factor of age.

Previous Hernial Repair—Most of the surgeons at the Clinic follow the general rule of repairing recurrent hernias with autogenetic fascia. In this series were 360 patients who previously had undergone operation many of them two to four times. Two patients each had been subjected to seven previous operations. In 258 of the 360 cases (approximately 72 per cent) autogenetic fascia was used whereas in only approximately 28 per cent was foreign suture material employed. The autogenetic fascial suture notwithstanding the fact that it was used for the larger and more difficult recurrent hernias gave favorable results. In recurrent

cases the tissues offer technical problems in dissection and in making satisfactory closure. To this is added the inherent weakness of scar tissue as compared to normal tissue. Besides the 360 patients who previously had been operated on there were forty three patients who had had sclerosing solutions injected before they came to the Clinic. Two of these patients had received seventy five injections each without curing the hernias and many of them had received from twenty to twenty five injections.

Site of the Hernia—Surgeons at the Clinic utilized autogenetic fascial sutures on a larger percentage of hernias than that on which they used sutures of foreign material (Table 2). A greater number of the larger hernias of all types were selected for autogenetic fascial repair than for repair with foreign suture material. This re-emphasized the fact that fascial suture is reserved for large difficult hernia.

Infection of the Wound—Table 3 gives evidence of the slightly greater incidence of infection of wounds among cases in which autogenetic fascial suture was used as compared with the cases in which foreign suture was employed. This is not unexpected because recurrence, obesity and large hernias would predispose to collection of serum which is an excellent medium for bacterial growth. However the rate of occurrence of infection among cases in which fascial suture was used in this series compares favorably with the average rate reported in the literature for cases in which nonabsorbable sutures were employed. Other factors making for contamination, namely the nasopharynges of operating room personnel, the patient's skin, the operating equipment and a prolonged time on the operating table, probably play more important roles than the type of suture selected by the surgeon. In recent years local application of sulfonamide drugs in some cases has appreciably reduced the incidence of infection of wounds as long as sound surgical principles have been followed.

Of the sixty eight cases of inguinal and ventral hernia in which appendectomy was performed along with the repair, post-operative infection of the wound developed in only one. This is contrary to the widespread belief that this procedure increases the hazard of infection.

Strangulation of the Hernia—Forty eight of the 2,336 patients died in hospital (a mortality rate of 2.1 per cent) of whom thirty one underwent concomitant major surgical procedures of

another type. Eight of these procedures were resections of the colon and twelve were operations on the stomach, gallbladder or spleen. Of the patients who died in hospital, eleven had incarcerated hernias and eight had strangulated hernias. These statistics support the opinion that early operative interference is desirable in cases in which there is potential danger of impairment of blood supply to the intestinal contents of the hernial sac.

TABLE 3
MORTALITY AND COMPLICATIONS

	Cases	Type of Hernia		
		Inguinal	Femoral	Ventral
Total (fascia and nonfascia)	2336	1459	104	773
Mortality per cent	2.1	0.8	1.9	4.4
Complications				
Pulmonary embolus	4	4	0	0
Respiratory	21	9	3	9
Phlebitis	8	5	1	2
Urinary tract	1	4	0	3
Infected wound	34	16	1	17
Fascia	21	13 (2.1%)	0	8 (3.4%)
Nonfascia	13	3 (0.4%)	1 (1.1%)	9 (1.1%)
Hematoma	11	8	0	3
Other	19	1	3	15

Other complications include gastric retention, hiccough, persistent fistula, anuria, persistent wound drainage, drug dermatitis, intestinal obstruction, cardiac irregularities, abdominal distention, wound disruption and undermining of the skin.

Of the patients who had strangulated hernias 19.5 per cent and of those who had incarcerated hernias 3.3 per cent died in hospital.

SUMMARY

The results of repair of hernias of 2,298 patients were studied. When autogenous fascia was used, the rate of recurrence was 7.8 per cent in contrast to 5.6 per cent for all other types of

suture material namely catgut silk cotton and so on. The slightly higher rate of recurrence in cases in which fascia was used is undoubtedly due to several important factors. Of these the main ones can be brought out rapidly by a series of implied comparisons as follows: (1) a much higher percentage of the patients in repair of whose hernias autogenetic fascia was employed were males; (2) a greater proportion of the patients in whose operations autogenetic fascia was used had been operated on previously; (3) a greater percentage of the hernias in repair of which autogenetic fascia was employed were large; (4) a larger percentage of patients in whose operations autogenetic fascia was employed wore trusses; (5) a greater percentage of patients in the autogenetic fascial series were obese and (6) proportionately more patients whose condition was remedied with autogenetic fascia were in the older age group.

The mortality rate in the total series was 2.1 per cent. In the cases of strangulated hernia the mortality rate was 19.5 per cent and in the cases of incarcerated hernia it was 3.3 per cent. Among the sixty-eight cases of inguinal and ventral hernia in which appendectomy as well as herniorrhaphy was performed there was only one case of postoperative infection. Among the sixty-seven cases of inguinal hernia in which orchidectomy was performed at the time of the hernial repair the rate of recurrence was only 3 per cent.

Taking all factors into consideration we believe autogenetic fascial sutures are preferable and more reliable for repair of hernias than foreign sutures especially if the hernias are large and repair is difficult.

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REMARKS ON VESICOVAGINAL FISTULA

VIRGIL S. COUNSELLER

Vesicovaginal fistulas result from difficult deliveries or from surgical or traumatic accidents. The number of patients presenting this condition continues about the same from year to year. The cause of the fistula has little to do with its surgical repair unless the fistula follows treatment with radium for cancer of the cervix. The factors which are of importance are (1) the period of time the fistula has been present (2) infection of the urinary tract (3) the location of the fistula (4) the type of surgical approach (5) the method of surgical repair and (6) postoperative care.

THE TIME ELEMENT

It has often been stated that to open the bladder during vaginal hysterectomy or vaginal plastic repair is not a serious accident provided immediate surgical repair is done. However, opening of the bladder is serious if the injury is unrecognized for then a fistula is certain to occur. Vesical tissue heals just as well as intestinal tissue but accurate approximation of tissue is just as essential in operations on the bladder as in those on the intestine since one contains water while the other contains fluid feces. Immediate repair of a torn bladder during delivery is practically always a success but interference with blood supply which may follow prolonged trauma will produce edema, necrosis and sloughing a few days after delivery and then it is necessary to delay repair for recovery and for the tissues to undergo proper involution.

The delayed fistula following surgical procedures almost always is secondary to a suture passing entirely through the bladder. Either the suture later sloughs out and produces the fistula or there may be too great an interference with blood supply such as may take place during total abdominal hysterectomy. This will probably be followed by a vesicovaginal fistula.

For the safe repair of these delayed fistulas it is advisable to

postpone surgical repair for six weeks to three months in order that all edema and other evidence of inflammation may subside completely. Failure to observe this one rule is one of the greatest causes of recurrence of the fistula. When multiple operations have been done in an attempt to close the fistula sufficient time should elapse to permit regeneration of blood supply and the softening of scar tissue. This may be a period of months.

INFECTION

Only a few vesicovaginal fistulas are associated with trouble some infection. These are usually the larger ones. The bladder in these instances becomes contracted, the mucosa may be covered with incrustations and it will bleed after their removal. I have observed large urinary calculi in the vagina which were producing necrosis from pressure and infection. The organisms which usually predominate are the urea splitting group and *Streptococcus faecalis*. Prior to the introduction of the sulfonamide compounds it was a major task to rid the bladder of these organisms and I am certain that residual infection was a real causative factor in recurrence since infection would break down the wound just as it will in any other situation. Recurrence was attributed to catgut suture material and therefore other material such as silver and steel wire, silk and now cotton was advocated to obtain good healing and avoid recurrence. I am inclined to believe that the secret is not suture material but clean wounds and clean urine. Formerly the usual trend of events was excellent convalescence for one week, then secretion began to pass from the vagina. Inspection of the suture line would reveal serous or purulent material oozing around the sutures followed in a few days by the escape of urine and another fistula developed. Secondary suture of the wound resulted in producing a larger fistula. All this has changed with the improvement in treating infections of the urinary tract. A few days of oral treatment with 30 grains (2 gm) of sulfathiazole daily will eradicate most of the infections except those due to *Streptococcus faecalis*. The latter will be cleared up satisfactorily by use of mandelic acid and ammonium chloride.

LOCATION OF FISTULA

The extreme importance of the location of the fistula with respect to the urethral sphincter, trigone, ureteral orifices and base

of the bladder cannot be overemphasized. In a recent article I¹ described these locations in considerable detail and referred to the surgical hazards that are associated with certain types.

I should like to stress the care of a fistula which involves the ureteral meatus. In this instance the upper part of the urinary tract becomes involved on the affected side by ureteral obstruction and infection. There are so many hazards that can occur in the surgical management of this situation that I usually select the one procedure which is foolproof. That is, if there is a sound kidney on the opposite side, I do preliminary nephrectomy of the involved kidney followed in ten days by closure of the vesico-vaginal fistula.

If the ureter is permitted to remain at its original site after the fistula is closed, chills, fever, cortical abscess and emergency nephrectomy are too frequently the sequelae. Should the ureter and kidney be free of infection and obstruction preoperatively, I should suggest cautiously that the ureter be reimplanted into the bladder above and well away from the fistulous tract and that immediate closure of the fistula be done. If the uninvolved kidney is faulty, it is unsound to perform nephrectomy on the involved side. In this case, I should say that cutaneous ureterostomy is the procedure of choice with later reimplantation of the ureter into the bladder if conditions are favorable.

In all discussions of this subject everyone emphasizes the importance of a cystoscopic examination to locate the fistula and determine the extent of urinary trauma. To this should be added a study of the excretory urograms if the fistula is located near or adjacent to the ureteral meatus.

TYPE OF SURGICAL APPROACH

There is not a universal or standardized surgical approach to all vesical fistulas but each case must be an individual problem. A well planned procedure should be outlined for each patient. The fistula may be approached vaginally, transvesically, or transperitoneally.

The result from any one of these methods may be successful but it is generally agreed now that the method of *transperitoneal approach* has many advantages over the others and that the operative risk which accompanies this method is practically nil. It seems to me that some of the advantages of this method should be stressed. Perhaps its greatest advantage is that it is extremely

simple and that is the type of operation every patient desires most especially if it cures her trouble. There is only one small vaginal incision to heal and this usually heals rapidly if it is approximated accurately. The obstetrician is well aware of this fact.

The position of the patient on the operating table is the cue to the accessibility of the fistula. The Sims position is most difficult and my colleagues and I never use it any more since the *kraskie* position affords so many other advantages. In this position the patient is placed on her abdomen with the buttocks raised on a kidney elevator. A Sims speculum is held firmly against the perineum a maneuver which raises the posterior vaginal wall and exposes the entire vagina and the anterior vaginal wall. The advantages of this position are obvious. It permits the surgeon to dissect directly down on the fistulous tract rather than through a dependent cavity as is necessary in the transvesical approach. The ureters can be catheterized with ease if it is advisable to do so when a laceration has extended laterally to the ureteral orifice. The ramifications of the tear in the wall of the bladder can be more nearly accurately identified. Since mobilization of the portion of the bladder containing the fistula and complete excision of the scar tissue are very essential parts of the operative procedure, there is all the more reason why the vaginal approach should offer the simplest and easiest way both for the patient and for the surgeon better chances of cure and considerably less disability.

The *transvesical approach*, I know is favored by many surgeons in preference to all other types. This I believe is due to a lack of familiarity with pelvic anatomy especially such as is required in vaginal plastic operations. When this method is selected it must be predetermined that the repair will be entirely successful otherwise the patient will have both a recurring vesicovaginal fistula and a suprapubic fistula together with a good possibility of a postoperative hernia. The surgical problem then is considerably greater than the original one.

There is one type of fistula which should be handled adequately by this method such as one in which it becomes desirable to reimplant the ureter in the bladder and to repair the fistula simultaneously. However my preference in handling this situation is to isolate the ureter retroperitoneally and if it is normal to reimplant it in the bladder well above the fistulous tract. Repair of the fistula would be delayed until the ureter had healed com-

of the bladder cannot be overemphasized. In a recent article I¹ described these locations in considerable detail and referred to the surgical hazards that are associated with certain types.

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dusted with powdered sulfathiazole and a nonirritating catheter is placed in the bladder

POSTOPERATIVE CARE

A good closure can be ruined by poor postoperative care such as failure to maintain a continuous flow of urine to support the patient comfortably on a Bradford frame or to keep the urine relatively free from infection. Formerly it was my practice to cleanse the vagina daily but I doubt if this is necessary. In fact it may be harmful. Copious vaginal drainage denotes an infected wound and such a wound cannot be sterilized by daily cleansing. It would be better to provide continuous irrigations with a 5 per cent solution of sulfathiazole in the vagina and to give the patient 30 grains (2 gm) of sulfathiazole a day by mouth, which will keep down the urea splitting organisms in the urine.

The use of the Bradford frame is a distinct advance in the treatment of vesicovaginal fistula by virtue of the fact that the incision is not bathed constantly in urine. The time required on the frame is ten to fourteen days. The patient rests on her abdomen and about 18 inches (46 cm) from the surface of the bed. The patient may observe the urine dripping from the catheter and call an attendant's attention to plugging of the catheter should this happen. This is a more serious complication than it would seem to be.

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A TECHNIC FOR CONTINUOUS CAUDAL ANESTHESIA AND ANALGESIA

R CHARLES ADAMS JOHN S LUNDY

and

THOMAS H SELDON

Blocking of the sacral nerves has been employed for many years to produce anesthesia for operations on or about the perineum the lower part of the rectum and the anus the bladder the pelvic floor and for obstetric delivery.¹ The duration of anesthesia is adequate for most operations and since the injection is extradural the method carries considerable appeal.

Several variations in technic have been employed.² In caudal block the injection is made into the caudal canal through the sacral hiatus. Transsacral block consists of blocking the first second third and fourth sacral nerves bilaterally in their respective foramina. Routine caudal block using 30 cc of 1 per cent solution of procaine hydrochloride or metycaine fails to produce complete anesthesia in about 20 to 30 per cent of operative cases. For this reason in sacral block at the Clinic we routinely use a combination of caudal and transsacral block. Another modification of the method is high caudal block,³ in which the amount of solution injected may be increased to 60 cc and perhaps as much as 90 cc of 1 per cent solution of procaine hydrochloride or metycaine.

The addition of the larger amounts of solution results in infiltration of the peridural space and produces peridural anesthesia. The height of the anesthesia will depend on the amount of solution injected. By using this technic it is possible to perform such operations as dilatation and curettage amputation of the cervix operation for cystocele and rectocele and vaginal hysterectomy. In some cases the anesthesia is incomplete and may have to be supplemented.⁴

In obstetrics caudal sacral block often has been used for delivery with satisfactory results. It has not been routinely successful partly because the pains of labor have been only partially relieved and partly because the duration of anesthesia

produced by the caudal sacral injection of a single dose of an anesthetic agent usually falls short of the length of delivery.

In 1940 Lemmon introduced continuous spinal anesthesia a technic which permits the injection of additional doses of the spinal anesthetic agent during the course of the operation. A similar technic, which has been adapted to caudal anesthesia by Hingson has been termed 'continuous caudal anesthesia'. A preliminary report on the use of this method by Edwards and Hingson recently has been published. The equipment employed is similar to that used for continuous spinal anesthesia namely a malleable needle of the Lemmon type connected by a small bore rubber tube to a syringe for injection of additional amounts of the local anesthesia solution. The needle is fixed in place with suitable pads and adhesive tape. Hingson has employed the method in a number of obstetric cases.

Since the preliminary report of the use of the method by Edwards and Hingson newer types of needles have been devised by them to obviate the potential hazard of breakage of the shaft of the needle where it joins the hub. By use of these improved types of needles and by having the patient lie on either side during the course of labor the danger of trauma and breakage of the needle and of infection is somewhat minimized. The use of a needle of this type produces consistently good anesthesia in the majority of cases since its position in the caudal canal may be adjusted accurately so that the solution is distributed evenly to all the nerve roots. We have used the method of Edwards and Hingson with satisfactory results except in a few cases where the needle broke and infection set in.

The technic for continuous caudal anesthesia as devised by the authors is presented as an alternative method. It is applicable for use both in obstetric and in surgical practice. This technic was devised to obviate the potential hazard of breakage of the needle and of trauma during the course of labor. Since the introduction of this method we have learned that a similar technic and similar equipment were used in obstetric delivery but not in labor by Mamlan of Indianapolis a few years ago. The method we are about to describe is suggested as an alternative technic in applying the method. It has the advantage of permitting the patient to lie in any position she desires during the course of labor and delivery and to move about with comparative freedom.

TECHNIC

The equipment and solutions used for obstetric procedures are the same as those employed for surgical procedures. With one exception the method of administration is the same for both procedures. In obstetric practice the anesthetic solution is administered while the patient is in the knee chest or modified Sims position; in surgical practice however the patient is placed in the prone position and the hips are elevated with pillows or with a sacral rest. We shall describe the technic that is used for obstetric procedures.

Equipment—The sterile continuous caudal tray should contain the following equipment:

- 1 No. 5 urethral catheter
- 1 13 gauge Loe Barker intraspinal needle and stylet
- 1 20-cc Luer Lock syringe
- 1 Luer wheeled needle
- 1 18 or 20 gauge Luer intravenous needle 1½ in. (3.77 cm.) long
- 1 16 gauge Luer hypodermic needle
- 1 Luer needle plug
- 1 Luer adapter
- 1 100 cc graduated cup

Solutions—The following solutions are sterilized and placed on the continuous caudal tray:

- 5 cc ampules of a 20 per cent solution of metycaine
- 2 1 cc ampule of 1:2600 solution of epinephrine
- Physiologic salt solution or triple distilled sterile water

Although we have used procaine hydrochloride to produce continuous caudal anesthesia we prefer metycaine because the duration of the resulting anesthesia is longer than that produced with procaine hydrochloride. Likewise the duration of anesthesia produced with 1.5 per cent solution of metycaine is longer than the duration of the anesthesia produced with a 1 per cent solution of this drug. A 1.5 per cent solution of metycaine is prepared by taking the contents of one 5 cc ampule of a 20 per cent solution of this drug and adding sufficient physiologic salt solution or triple distilled water to make a total of 66.6 cc.

If the patient's blood pressure is not abnormally high and if

As we have continued using the catheter technic it has appeared that a 15 gauge needle and a No. 4 catheter are preferable to the regular 13 gauge needle and No. 5 catheter. The 15 gauge needle is easier to insert and causes less trauma.

there are no other contraindications 1 cc of a 1:2,600 solution of epinephrine is added to the 66.6 cc of 1.5 per cent solution of metycaïne. The addition of epinephrine increases the duration of anesthesia, in some cases this increase is as much as 100 per cent. The induction of anesthesia can be hastened by having the solution warm when it is injected.

Premedication—Premedication with a barbiturate such as pentobarbital sodium (nembutal) is sometimes desirable for two reasons: first, it helps to relieve the preliminary labor pains and second it is a prophylactic against untoward reactions of the anesthetic agent. However it must not be given to a patient where it interferes with her ability to cooperate by bearing down during delivery.

Administration of the Anesthetic Agent—The administration of the anesthetic agent may be started in the patient's room or in the predelivery room. In cases in which the patients are primiparas the injection is begun when the dilatation of the cervix reaches 2 or 3 cm and when the pains have become moderately severe. The injection may be administered somewhat earlier however in cases in which the patients are multiparas and labor is advancing rapidly.

The patient is placed in the knee chest position and the sacral region is sterilized and draped. A skin wheel is raised over the sacral hiatus and the Luer intravenous needle is inserted just through the sacrococcygeal ligament. Five cubic centimeters of the local anesthetic solution is introduced at this point. This needle is withdrawn and the 13 gauge Love Barker needle with its stilet in place is introduced through the sacrococcygeal ligament with the bevel directed upward and with the needle held at an angle of about 45 degrees with the ordinary vertical axis of the body (Fig. 337). When the point of the needle lightly impinges on the bone of the anterior wall of the sacral canal the bevel of the needle is turned downward and the hub depressed so that the point of the needle may be advanced upward along the caudal canal. It should not be necessary to insert the point of the needle past the level of the third sacral foramen. In passing the needle through the canal it is advanced cautiously care being taken to prevent scraping the bony walls and thereby injuring the venous plexus lining the canal.

The stilet is then removed and the No. 5 ureteral catheter is threaded through the needle into the caudal canal and is ad-



Fig 337.—The 13 gauge needle has been inserted into the caudal canal to the level of the third sacral foramen. The skeleton has been partially withdrawn.

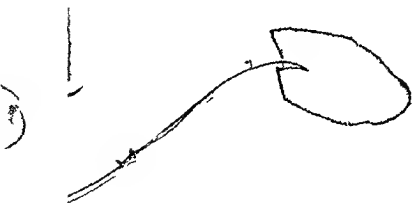


Fig 338.—The stylet has been withdrawn from the 13 gauge needle and the catheter has been introduced through it into the caudal canal.

vanced to bring its tip to about the level of the second sacral foramen or between the second and third foramina (Fig 338). The length of catheter necessary to reach this level is deter-

mined by previous measurement externally. Graded catheters facilitate approximation of the correct measurement. The 13 gauge needle is then withdrawn over the catheter leaving the latter in place in the caudal canal. The catheter should be held in position as accurately as possible during the maneuver in order to keep the tip in the desired position. At this time 5 cc of the local anesthetic solution is injected through the catheter into the caudal canal to check the patency of the catheter. It

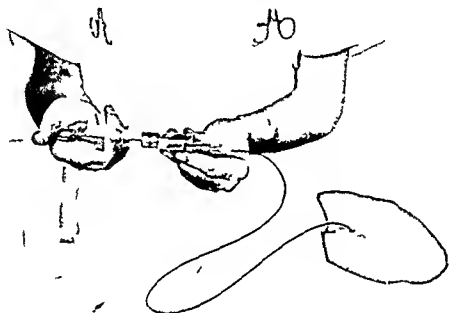


Fig 339—A No 5 ureteral catheter has been introduced into the caudal canal through the 13-gauge needle and the needle has been withdrawn over the catheter. This shows the preliminary injection of 15 per cent solution of metycaine through the catheter into the caudal canal prior to the fixation of the catheter with adhesive tape.

also is advisable to check the patient's reaction to a small dose of the drug before a large amount is injected (Fig 339).

The ureteral catheter is then strapped firmly in position with waterproof adhesive tape and several broad pieces of tape are placed over the point of entry to protect the region from soiling or contamination (Fig 340). The remaining portion of the catheter is curved laterally and is strapped to the skin in several places so that the end comes to lie along the flank. The open

end of the catheter must of course be kept sterile during these maneuvers and at this time a 22 gauge Luer hypodermic needle is inserted into the lumen of the catheter. This may be kept sterile between injections by a Luer cap or by placing a sterile sponge over it and fastening the cover by adhesive tape or an elastic band. The hub of the 22 gauge needle is attached to the catheter by a small strip of adhesive tape to prevent its becoming dislodged from the end of the catheter.

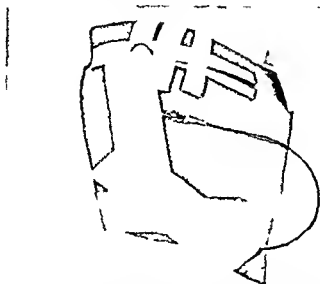


FIG. 340—The exit of the catheter from the skin is thoroughly fixed with terproof adhesive tape both to hold it in place and to prevent contamination of the point of exit by siphoning. The catheter is carried across laterally and fixed to the skin over part of its length by adhesive tape. A 20-gauge Luer needle has been inserted into the distal end of the catheter and fixed in place by a small piece of adhesive tape. Between the hub of this needle is inserted and kept tightly a Luer cap. The end of the catheter is carried around to the flank so that it rests in an accessible position for repeated injection.

The preliminary injection of 20 cc of the anesthetic solution may now be made. The solution is introduced very slowly 10 cc at a time. Too rapid an injection or the injection of too much solution at any one time may cause pain, nausea, headache and other effects owing to too much pressure within the caudal canal. When the preliminary injection is completed the patient may be turned over on her back or may be in any position she desires. If the catheter has been properly fixed the patient may

roll in bed or turn in any position without dislodging the catheter

When she again becomes aware of pains 10 or 20 cc of the solution of metycaine is injected. This injection is repeated as often as necessary during the course of labor or delivery. The anesthesia should be adequate for any operative manipulation such as forceps delivery, episiotomy, perineal repair and so forth. Before the patient is returned to her room the catheter is removed from the caudal canal, the site of the puncture is painted with an antiseptic and a sterile dressing applied.

PRECAUTIONS AND POSSIBLE COMPLICATIONS

The large size of the Love Barker needle makes for trauma if the catheter comes out of the canal and has to be replaced. The site of trauma may become infected and a bit annoying for a few days before the injury heals. If infection does occur its course may be shortened by the use of hot, wet dressings and the administration of sulfathiazole by mouth. The ureteral catheter should be carefully examined before use for defects and the patency of its lumen should be checked by injecting sterile normal salt solution through it. Old or defective catheters should be discarded. The catheters may be sterilized by boiling or cold sterilized in antiseptic solution. Between deliveries they are coiled in a sterile circular container or towel to prevent kinking or undue angulation.

Poor anesthesia may be the result of one of the following causes: (1) If the solution is deposited too high it may fail to contact all the sacral nerves and result in incomplete anesthesia. (2) The catheter may become curled up within the canal, deflecting the tip to one side or backward toward the hiatus. This also may result in incorrect distribution of the solution with resultant inadequate anesthesia. (3) When the catheter has been advanced too far into the caudal canal and it becomes necessary to withdraw it to the proper level, the 13 gauge needle should be withdrawn as well and both the needle and the catheter reinserted. If an attempt is made to withdraw the catheter without withdrawing the needle, the catheter may become caught on the sharp bevel of the needle. Traction on the catheter under such circumstances may result in shearing off the tip in the caudal canal. (4) The catheter may be too slender to be manipulated properly.

COMMENT

From our experience up to this time the method would appear to have merit. The results obtained in obstetric delivery will be published subsequently by the Section on Obstetrics. The results of its use as an anesthetic for surgical operations also will be published at a later date.

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RELATION OF VITAMIN B TO THE DURATION OF ANESTHESIA INDUCED BY PENTOBARBITAL SODIUM

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The period of anesthesia induced in experimental animals by a given anesthetic agent when administered intravenously in constant amounts is exceedingly variable. Certain animals seem able to destroy the drug quickly, others require periods twice to three times as long. The liver was thought to destroy pentobarbital sodium¹⁻³ but was without effect on pentothal sodium. The liver plays an important role in the destruction of certain steroid hormones⁴ but is without effect on ether or magnesium chloride. Physiologic states associated with sex appear to be a factor, for female rats slept twice to three times as long as males when given comparable amounts of pentobarbital sodium.⁵ When daily doses were given, the sleeping time decreased abruptly. When testosterone propionate was given to female rats the period of anesthesia induced by comparable amounts of the drug was cut essentially in half.⁵ Sex however did not appear to be a factor in rabbits³ or guinea pigs.⁴

The physiologic state of an animal must largely control the speed with which any drug is destroyed. Vitamin C deficiency greatly prolonged the sleeping time of guinea pigs when anesthesia was induced with pentobarbital sodium but was without effect on the duration of anesthesia induced by the ultra short acting barbiturate pentothal sodium.⁷ Hepatic glycogen is decreased in vitamin C deficient animals. Fatty degeneration of the liver developed in guinea pigs and rabbits fed vitamin C deficient diets.¹⁰ The prolonged anesthesia induced in vitamin C deficient guinea pigs was not due to decreased stores of hepatic glycogen to inactivation or to increased hepatic fat.⁷ for the sleeping time of such guinea pigs could be shortened to periods established for normal animals by giving ascorbic acid. Rats which were fed a choline free diet had fatty livers in two to three weeks and slightly longer sleeping periods were observed in these animals than in rats fed an adequate ration.⁶

Since the liver is known to be instrumental in destroying some of the barbiturates⁶ and since this organ is rich in some of the fractions of vitamin B we have studied the duration of anesthesia in rats maintained on a synthetic diet which was adequate with respect to dietary requirements except vitamin B. This report covers the results of these observations.

METHOD

Adult male white rats six months old having an average weight of 259 gm. were used. They had fed on our standard laboratory ration since weaning. Pentobarbital sodium (nembutal) was the anesthetic used. It was given intravenously in amounts equal to 25 mg. per kilogram of body weight in sterile physiologic salt solution. Kinsey used 31.3 mg. per kilogram.⁷ Carmichael showed that the minimal lethal dose was 85 to 95 mg. per kilogram for old rats and 110 to 120 mg. per kilogram for young rats. Although many workers use the intraperitoneal route to administer the drug we have preferred to give it intravenously. The effect is immediate and the animal is asleep by the time the injection is complete. When the drug is given intraperitoneally the effect is more prolonged and the rates of absorption appear to vary greatly. We accepted as the duration of anesthesia the interval from injection to the time the animal was sufficiently awake to right itself and turn over.

The duration of anesthesia was first established for a group of ten animals which ate our standard laboratory ration (experiment 1). Thereupon all animals were placed on a synthetic ration consisting of vitamin free casein (70 parts) * glucose (69 parts) hydrogenated vegetable oil (Crisco) (3 parts) inorganic salt mixture (4 parts) † agar agar (2 parts) and cod liver oil (2 parts). All ten animals were provided this diet for five weeks. The average duration of anesthesia induced by pentobarbital sodium in amounts proportionate to their weights was again determined (experiment 2).

These ten animals were then placed on a replacement regimen (experiment 3). They continued to eat the synthetic diet but they were given in addition by stomach tube 1 cc. of a vitamin B mixture made to contain the following fractions: thiamine hydrochloride, riboflavin, pyridoxine, pantothenic acid, niacin, inositol and choline. These vitamins were prepared for use in

* Iabco brand Casein C. F. America

† Hart's Laboratories

such concentrations that 1 cc of the mixture contained 50 micrograms of thiamine 25 micrograms of riboflavin 25 micrograms of pyridoxine 100 micrograms of pantothenic acid 0.35 mg of niacin 8 mg of inositol and 5 mg of choline. We are indebted to Merck and Co for a generous supply of these fractions and for their continued interest in our studies. These amounts may not be optimal but satisfactory recovery and growth occurred in these ten deficient rats.

Five rats were then taken off the supplementary tubing regimen and as soon as their food intake and their body weights began to drop they were again tested for the duration of anesthesia (experiment 4). Since the amount of food consumed by these animals from which vitamin B was withheld had dropped from 10 or 12 gm daily to 5 or 6 gm daily we thought it necessary to control the nutrition factor. Accordingly these five animals were restricted to 5 gm of food per day per rat but they were given by stomach tube the vitamin fractions set forth previously. After two weeks of this regimen of a reduced food intake supplemented by the vitamins we again tested for the duration of the period of anesthesia (experiment 5).

RESULTS

All data have been assembled and condensed into the accompanying tabulation. Healthy adult rats that were fed the laboratory ration when given the anesthetic dose of 25 mg per kilogram slept for periods ranging from seventeen to thirty nine minutes (experiment 1). The weight of the animal was not a factor regulating the waking time. The largest animal (320 gm) received 8.0 mg of the drug and awoke in eighteen minutes. The smallest animal (205 gm) received 5.12 mg of the drug and awoke in thirty two minutes.

When these animals were placed on the vitamin B free synthetic diet they maintained their weight levels for a few days and then as appetite failed less food was taken and their weights rapidly fell. Long before organic symptoms of any marked deficiency had appeared and when they had lost about 40 per cent of their attained weights all animals slept more than twice as long as before when given proportionate amounts of pentobarbital sodium. The average sleeping time was 67.7 minutes an increase of about 135 per cent over the previous sleeping time tested when all animals were eating an adequate ration.

(experiment 2) In this group the largest animal slept fifty one minutes the smallest sixty four minutes and the animal sleeping the longest (109 minutes) weighed 146 gm.

Within a few days after institution of the daily tubing regimen whereby each rat was given 1 cc of the vitamin B fraction mixture the food intake increased and weight increments were recorded. After the loss of weight sustained during the period when these animals ate the vitamin B free synthetic diet had been essentially regained we again gave them proportionate amounts of the drug and recorded sleeping periods equal to those observed when the animals were eating the laboratory ration (experiment 3). In the first test the average time between the injection of the drug and the awakening of the animal had been 28.8 minutes. In the third test when animals ate the synthetic ration and were given the fractions of the B vitamin the sleeping time was 26.6 minutes. These means are of course statistically similar. Here again one of the larger rats (280 gm) awoke in the shortest time (eighteen minutes). The longest period of anesthesia (thirty seven minutes) was experienced by a rat weighing the least except one of the ten animals (205 gm).

It was apparent that vigorous well nourished animals were anesthetized for shorter periods by proportionate amounts of the drug than were poorly nourished ones. Consequently we determined the duration of anesthesia in animals which were fed the same amount of food daily as was taken normally by animals which were subjected to some degree of vitamin B deficiency. Accordingly five of the ten animals (experiment 4) continued to eat the synthetic ration but were not given the daily vitamin supplement. As soon as their body weights began to decline and their daily food intake had perceptibly dropped we again tested them for the duration of anesthesia. Each had lost about 20 gm their food intake had dropped to 6 or 7 gm per day and their average period of anesthesia had now increased from 26.6 minutes to 52.8 minutes. It will be observed that this average period (52.8) was considerably less than that (67.7) recorded when the animals were previously tested (experiment 2). At that time the symptoms of vitamin B deficiency were more marked and the loss of weight was more severe.

These vitamin B deficient rats with an increased period of anesthesia were eating between 5 and 6 gm of food each day.

All were then restricted to 5 gm of food each day but in addition all were provided with the vitamin supplements. In this way all of the essential fractions of vitamin B were provided but the food intake was restricted. After two weeks of this regimen these rats were again tested for the duration of anesthesia and an average of 37.8 minutes was recorded. This period of elapsed time was greatly reduced but was not as short as when these animals ate either the standard ration or the synthetic ration and were provided the vitamins daily. The extent of absorption of the vitamin fractions is of course not known but the vitamin requirement was less in the presence of a suboptimal food intake so that a considerable amount of the vitamin supplement may not have been utilized. The data indicate that when the vitamins were provided and the food intake was kept constant the duration of anesthesia induced by constant amounts of the drug was shortened.

SUMMARY AND CONCLUSIONS

The duration of anesthesia which followed the intravenous injection of proportionate amounts of pentobarbital sodium has been determined for ten white rats which were maintained on dietary regimens as follows: (a) our adequate standard laboratory ration; (b) a synthetic diet free of vitamin B; (c) the same synthetic diet supplemented with known amounts of thiamine, riboflavin, pyridoxine, nicotinic acid, pantothenic acid, choline and inositol daily; (d) the same synthetic diet supplemented by these vitamins, each animal being allowed the amount of food daily which a rat when experiencing a moderate degree of vitamin B deficiency will consume.

The following conclusions were drawn:

1. The average period between the time of injection of the drug and the time of awakening was 28.8 minutes for healthy animals fed an adequate commercial ration.

2. When these same animals were maintained on a synthetic ration adequate except for vitamin B they remained asleep following proportionate injections of the same drug for an average time of 67.7 minutes.

3. When these same animals continuing to eat the synthetic ration were given 1 cc of the vitamin B mixture their food intake rapidly increased and they rapidly regained weight. When proportionate amounts of the drug were injected again

the period of sleep decreased on the average from 67.7 to 26.6 minutes

4 When the amount of food that the rats were permitted to take was restricted but they received the vitamin mixture as well the average sleeping time was 37.8 minutes. This average time was considerably less than the average time of anesthesia (57.8 minutes) experienced by the same rats when they ate comparable amounts of food but were not given the vitamin supplements

The data do not prove that the rapid destruction of the drug in animals adequately provided with vitamin B was due to a high concentration of these principles in the liver. It is known

TABULATION
EFFECT OF VITAMIN B ON DURATION OF ANESTHESIA

Experiment	Treatment	Animals	Body Weight, gms.	Pentobarbital Sodium, m.	Duration of Anesthesia, minutes
1	Laboratory	10	288 ± 8.3 (320)	45 ± 0.21 (12.800)	28.8 ± 1.6 (17.3)
2	Synthesized (B)	0	151 ± 6 (110-204)	30 ± 0.16 (2.750)	6.7 ± 3.7 (48-109)
3	Highly purified (B)	30	248.0 ± 7.6 (0.5-290)	0 ± 0.29 (4.75-7.00)	26.6 ± 1.1 (18.3)
4	Synthesized (B free)	5	224.4 ± 8.7 (190-680)	5 ± 0.18 (4.7-6.50)	52.8 ± 2.9 (4-64)
5	Synthesized (B free) (plasma)	5	232 ± 4.1 (95-26)	5.94 ± 0.12 (4.88-6.85)	37.8 ± 1.5 (30-47)

Figures in parentheses

through studies elsewhere that the liver is rich in these vitamin fractions. It is known too that the liver is probably one of the sites for the effective destruction of pentobarbital sodium. But it is not known that the liver is an effective organ for destroying the drug because of its high content of these vitamin fractions. The factors which make the organ so effective a defense mechanism against some of the barbiturates must await further study.

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ANESTHESIA IN RELATION TO SHOCK

HIRAM E. ESSEX

The literature on the subject of traumatic shock has become so voluminous that Harkins¹³ in a recent review listed 848 titles which required more than thirty pages to print. Consequently in an article limited in space it is out of the question to review the literature or to discuss more than a single phase of the problem. Therefore this paper will be concerned chiefly with a consideration of data obtained from experiments on shock produced by various methods and by the use of different anesthetic agents.

General anesthesia regardless of the agent used exerts a wide variety of effects on the physiologic processes of the subject anesthetized.^{1, 2, 4, 20} This is true to a less extent of spinal anesthesia.⁴ Although considerable attention has been given to the pharmacology of anesthetic drugs, our knowledge of their action on the normal subject is very incomplete; to say nothing of our knowledge of the effects produced on subjects whose normal physiologic processes have been altered by disease or other injury. In recent years more attention has been given than in earlier periods to the part played by anesthetic agents in the experimental production of shock as well as to the choice of the agent when operation is necessary and shock is present or is suspected of being imminent.^{6-11, 24, 29}

SHOCK AND HEMORRHAGE

There are many ways of producing shock experimentally in animals. Reduction of the volume of blood by *missile or repeated hemorrhage* is a method that has been used by many investigators. The blood may be withdrawn with the animal under local or general anesthesia from an artery or from a vein. It may be removed slowly or rapidly. Usually more blood may be removed without seriously affecting the blood pressure if it is removed slowly from a vein than if it is removed from an artery. The total volume of blood that may be removed

before a marked decrease of blood pressure occurs varies within wide limits in different animals

Adolph Gerbasi and Lepore found, following hemorrhage that the fluid from the extravascular spaces migrated into the circulating plasma at the rate of about 0.25 cc per kilogram of body weight per minute and about twenty two minutes were required for approximate completion. The complete or partial restoration of blood pressure following hemorrhage is owing in part to this mechanism. Some recent experimental evidence presented by Ivy¹ furnishes a clear idea of how resistant some animals are even to massive hemorrhage. In his experiments dogs were allowed to bleed from a carotid artery cannulated with the animal under local anesthesia. The blood was allowed to flow without interruption until the flow ceased spontaneously. The final loss of total blood volume was from 45 to 67 per cent and this occurred in from seven to twenty minutes. It is surprising to note that 15 per cent of the animals survived hemorrhages of this magnitude. Moon, Morgan, Lieber and McGrew² have reported that unanesthetized dogs tolerate about twice as much hemorrhage as animals under amytal anesthesia. They stated that a loss of blood amounting to 91 per cent of the body weight caused 77 per cent hemodilution and death in thirty one and a half hours without anesthesia while half as great a loss of blood caused death in thirty one and a half hours during the last six and a half hours of which the animal was under amytal anesthesia.

Roome, Keith and Phemister³ lowered the blood pressure of dogs by nine different methods among which were section of the spinal cord, spinal anesthesia, trauma to an extremity and intestinal manipulation. After one hour of reduced blood pressure the animals were bled to death and the volume of blood obtained was calculated in terms of the original estimated blood volume. Roome and his associates³ found that the average volume of blood obtained from animals whose blood pressure was lowered by section of the spinal cord or by spinal anesthesia was much greater than when the blood pressure had been lowered by hemorrhage, trauma to an extremity or intestinal manipulation. In a control series of experiments they compared the results of bleeding dogs under ether and under barbital sodium anesthesia. The average percentage of blood removed before death ensued was respectively 54.8 and 72.4. These in

investigators concluded that the volume of the circulating blood is not seriously diminished and consequently operation or loss of blood is well tolerated in conditions of lowered blood pressure resulting from vasodilator mechanisms such as spinal anesthesia administration of histamine and certain surgical procedures but that quite the contrary is the case when the blood pressure had been reduced by hemorrhage trauma to an extremity or intestinal manipulation

In a series of experiments with dogs under ether anesthesia Mann Herrick Baldes and I¹⁷ while observing the effect of hemorrhage on blood flow in certain vessels withdrew slowly (at intervals over a period of one to three hours) from the jugular vein as much as 60 per cent of the estimated total blood volume before death occurred. The blood flow in the carotid artery was less affected than that in the femoral artery. In one experiment when the blood flow in the femoral artery had decreased to about 50 per cent of the control value the animal had lost about 35 per cent of the estimated total blood volume but even so there was sufficient cardiovascular compensation to maintain the blood pressure near the control level. With further withdrawal of blood a physiologic blood pressure was maintained until only a few minutes before death when the blood pressure decreased suddenly to near zero the blood flow in the femoral artery temporarily increased and the animal died.

Price Hanlon Longmire and Metcalf have made an able investigation of the physiologic effects of acute hemorrhage in healthy dogs under pentobarbital sodium (nembutal) anesthesia. These authors concluded (1) that progressively severe anoxia occurs as a result of massive hemorrhage (2) that the vital centers do not share at first in this general lack of oxygen but probably share in it later (3) that relaxation of vasoconstriction did not occur although Price and his associates did not exclude its occurrence just before death (4) that congestion was absent (5) that partially exsanguinated animals became extremely sensitive to further loss of blood at a certain stage of which the removal of an additional few cubic centimeters caused immediate collapse (6) that capillary atony did not appear nor was there any evidence of abnormal capillary permeability and (7) that even larger proportions of infused fluids such as isotonic saline solution serum or whole blood leave the blood stream when the fluids are injected into normal animals than

after their administration to animals in shock from hemorrhage. These findings if shown to be true in all types of experimental shock, have dealt a severe body blow to many cherished explanations of the probable cause of the irreversible state that is reached after the circulation has been at a critical level for a sufficient length of time.

From these investigations it may be emphasized again (1) that the state of the blood pressure may not adequately reflect the circulating blood volume and therefore is not a reliable criterion of impending shock (2) that if hemorrhage has occurred is a result of injury or otherwise it may have been greater than suspected and much greater than the general appearance of the patient might indicate (3) that it is advisable to proceed with the utmost caution in anesthetizing patients who have sustained severe injuries since anesthesia may precipitate shock in those that have been injured severely or that have had hemorrhage of considerable magnitude and (4) that when whole blood or plasma is not available other fluids such as isotonic saline solution should be given if severe hemorrhage has occurred.

SHOCK PRODUCED BY INTESTINAL TRAUMA

One of the most common methods of producing shock experimentally is by intestinal manipulation and exposure. With the animal under some form of general anesthesia the small intestine is brought to the outside where it is manipulated and left exposed. The trauma is usually administered for a specified period ranging from thirty to forty minutes. It has been the practice in this laboratory to turn the intestines every thirty minutes after the initial trauma. In addition to recording the mean blood pressure changes of the concentration of hemoglobin the hematocrit reading temperature or any other phenomenon may be followed.

Using this method Seeley, Mann and I studied the development of shock in dogs under ether and under amytal anesthesia and combinations of the two agents. The mean blood pressure the concentration of hemoglobin and the temperature were followed. With the animal under ether anesthesia shock which was considered to be present when the blood pressure decreased to and remained at or less than 70 mm of mercury developed in about four hours and death occurred on an average about

two hours later. At the time of the onset of shock the hemoglobin had concentrated to about 130 per cent the control hemoglobin concentration being considered 100 per cent. In contrast animals under amytral anesthesia reached the shock state in about eleven hours and thirty minutes and death occurred about three hours later. The concentration of hemoglobin was about 88 per cent after anesthesia but was about 138 per cent at the time shock was presumed to have developed. With both anesthetic agents the rectal temperature declined several degrees before shock and death occurred. That sodium amytral had a protective action against the development of shock in the presence of ether anesthesia was shown by combination of the two agents. Recently Beecher, McCarrell and Evans⁵ have reported a confirmation of our findings but these workers failed to obtain similar results when they produced shock by traumatizing limbs. A discussion of their results can not be made here.

Kendrick¹⁰ compared the rate at which shock developed under ether and pentobarbital sodium anesthesia using methods similar to those employed by Seeley, Mann and me and his results were strikingly similar. Shock developed in about four hours on an average in the animals anesthetized with ether and in about thirteen hours in those anesthetized with pentobarbital sodium.

Recently in association with members of the Section on Anesthesia of the Clinic I have carried on a number of studies concerned with anesthesia in traumatic shock. Pender and I¹¹ observed the development of shock by intestinal trauma in dogs under ether, under pentobarbital sodium and under pentothal sodium anesthesia. In the series of dogs under ether anesthesia shock developed in the shortest time, in those under pentothal sodium in the next shortest time and those under pentobarbital sodium went into shock most slowly and lived longest. The details of the findings were in essential agreement with those of previous studies in which ether and pentobarbital sodium were used. In the series of animals anesthetized with pentothal sodium as needed throughout the experiment shock developed on an average in about ten hours and death occurred about an hour later.

Because of the growing importance of pentothal sodium in military medicine and because it had been thought inadvisable

to anesthetize patients with this agent when the blood contained therapeutic concentrations of sulfanilamide Captain Hool of the Medical Corps United States Navy requested that a research be carried out to test whether such precautions were necessary Pender Ashburn and I^o performed a series of experiments in which shock was produced in dogs by intestinal manipulation under pentothal sodium anesthesia alone and in dogs that previously had received sufficient sulfanilamide by mouth to make the concentration in the blood 10 to 20 mg per 100 cc The latter group lived as long as the animals whose blood did not contain sulfanilamide and shock did not develop more rapidly in those that had received sulfanilamide than in those that had not received it

Anderson and I^s assessed the value of various *premedicant agents* in delaying death produced by manipulation of the intestine of an animal under ether anesthesia Three of the drugs commonly given before general anesthesia were observed morphine sulfate atropine sulfate and pentobarbital sodium employed singly or in combination Morphine sulfate when used alone as the premedicant agent in doses similar to those used clinically (0.25 mg per kilogram of body weight) was ineffective but doses of 1.1 to 2.0 mg per kilogram of body weight were very effective Atropine sulfate used alone in doses of 0.0065 mg per kilogram of body weight was equally effective while pentobarbital sodium alone was somewhat less effective in delaying death than morphine (in large doses) or atropine When atropine was combined with either of the other two premedicant agents the results were about the same as those obtained with atropine alone In short under the conditions of these experiments atropine sulfate appeared to be able to do as much as or more than the other premedicant agents singly or combined in delaying death

COMMENT

The suggestion has been made that one might learn more about traumatic shock if anesthesia could be omitted entirely but Wiggers⁷ in his recent monograph has pointed out that anesthesia simplifies the interpretation of cardiovascular responses arising during the production of traumatic shock and is indeed more of a help than a drawback to the investigator In his opinion the ideal anesthetic agent for studies of shock is one

that is given intravenously that alters natural reflexes and cardiac action as little as possible that maintains even anesthesia for hours without readministration and that does not induce circulatory states that can be confused with shock. According to Wiggers these criteria are best met by one of the barbiturates combined with premedication with morphine. With regard to the barbiturate I thoroughly agree but I must reserve judgment on the value of morphine since in our experience it was not of benefit combined with ether anesthesia except when given in relatively large doses.

It must be borne in mind that the ideal or perfect anesthetic agent or combination of agents has not yet been discovered and that all anesthetic drugs are particularly dangerous when administered after massive hemorrhage, severe injury or a combination of the two. Spinal anesthesia may not reduce the circulating blood volume but spinal anesthesia superimposed on a reduced circulating blood volume resulting from hemorrhage or injury may cause sufficient vasodilatation to make the discrepancy between circulating blood volume and the capacity of the vascular system such that circulatory collapse may ensue.

The point seems to be well established that after intestinal manipulation shock develops more slowly and animals live longer under the barbiturates than under ether anesthesia. It has been pointed out by Beecher and others⁷ that this fact does not necessarily indicate that the barbiturates would delay the onset of shock in one who has been injured severely; in other words the barbiturates are not recommended as a prophylactic for shock. With this position I am in complete agreement.

SUMMARY

From a consideration of certain experimental evidence it is again emphasized (1) that the state of the blood pressure may not adequately reflect the circulating blood volume and therefore is not a reliable criterion of impending shock. (2) that if hemorrhage has occurred as a result of injury or otherwise it may have been greater than suspected and much greater than the general appearance of the patient might indicate. (3) that it is advisable to proceed with the utmost caution in anesthetizing patients who have sustained severe injuries since anesthesia may precipitate shock in those who have been injured severely or who have had hemorrhage of considerable magnitude. (4)

that when whole blood or plasma is not available other fluids such as isotonic saline solution or solution of acacia should be given if severe hemorrhage has occurred (5) that the barbiturates are more effective in delaying shock and death than ether anesthesia when shock is produced by intestinal manipulation but that the administration of the barbiturates is not recommended as a prophylactic measure against shock to be used for the injured (6) that the presence of therapeutic concentrations of sulfanilamide in the blood of dogs did not produce any untoward effect when the animals were anesthetized with pentothal sodium (7) that atropine was more effective as a premedicant than morphine or pentobarbital sodium in delaying death under the conditions of the experiments on shock in which these drugs were used

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THE SURGICAL CLINICS OF NORTH AMERICA

THE TREATMENT OF BURNS*

HENRY N HARKINS MD PhD FACS†

BURN treatment is a subject of ever increasing importance. The high incidence of burns among battle casualties in the present war needs no re emphasis. The very importance of the subject however has led to so many new and recent modes of therapy that there exists a need for clarification at this time of the general principles of burn treatment. Only by a clear understanding of such principles can a logical choice of therapy be made in any particular burn case.

For convenience the treatment of burns may arbitrarily be divided into four phases as follows

- I General treatment of the burned patient
- II Local care of the burn wound
- III Early plastic care of granulating surfaces (in third degree burns)
- IV Late plastic care of deformities

In this paper only the first three of these phases will be discussed. This is done because these three elements of burn treatment should be performed concurrently and conjointly one is not complete without the others and two of the three alone are not enough and because they must often and preferably should be performed by the same surgeon. In other words for proper care of a severe burn the general care local care and early plastic care should be made to flow smoothly one into the other. Delays between them are dangerous. Good local treatment without adequate general care may lead to a clean wound but a dead patient. Similarly proper early care without prompt

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grafting of granulating surfaces is like doing a cholecystectomy and then forgetting to close the abdominal wound

Contrariwise the late plastic correction of burn deformities and scars once the granulating surface is healed should often be delayed several months is usually not urgent can wisely be performed by another surgeon perhaps thousands of miles away and is a separate chapter in the care of any particular burn patient

More detailed consideration will now be given to the coordinated application of the first three phases of burn treatment

I THE GENERAL TREATMENT OF THE BURNED PATIENT

The general treatment of the burned patient is of extreme importance Three complications are to be prevented and treated namely burn *shock* burn *toxemia* and burn *sepsis* Of these three the treatment of shock is probably the most essential but toxemia and sepsis should not be forgotten The value of adrenal cortical extract in the control of toxemia is still unproved but adequate amounts of glucose and protein to protect the liver are of definite help Certain local treatments such as tannic acid especially in jelly form may increase the tendency to liver necrosis Erb Morgan and Farmer (1943) reported an analysis of sixty one burn necropsies Forty one of the patients had been treated with tannic acid and of these twenty five (61 per cent) showed definite liver necrosis at necropsy Twenty of the patients had not been treated with tannic acid and of these none showed definite liver necrosis at necropsy The control of sepsis is especially aided by the sulfonamide drugs but probably far more important are the prophylactic measures which include cleanliness and aseptic local care as will be discussed later Except when the patient is vomiting sulfonamides can be taken by mouth and if the presence of nausea makes it necessary they can be given parenterally Standard and empiric methods of treating shock have some value but should not delay the all important administration of plasma or plasma substitutes Elevation of the foot of the bed oxygen, morphine rest, quiet and conservation of body heat are all of value The application of external heat may prove detrimental as shown by Blalock and Mison (1941)

Administration of Plasma

In the early stages of burn treatment the control of shock is all important as shown by Lee Elkinton and Wolff (1941) and others. This period usually includes the first thirty six hours in severe burns. Burn shock is essentially, even though not entirely due to the loss of blood plasma from the weeping burned surface and into the damaged burned tissues. Consequently efforts should be made to control the loss of plasma and to restore the blood volume by an amount of plasma equal to that already lost. Crystalloid solutions (saline, glucose Ringer's solution etc.) are of only temporary value in this respect as they tend to leak out of the injured blood vessels. Whole blood is useful but the erythrocytes are of no value at this stage of burn treatment and make blood typing and cross matching necessary. Plasma is lost and plasma should be restored. Elman (1943) found on analyzing seventy eight fatal cases of burns that failure to use plasma transfusions at all or in inadequate amounts was one of the chief factors contributing to early mortality.

Of especial importance is the *amount* of plasma that is given. It is no more logical to give every burned patient just one pint of plasma than to give every diabetic patient just 10 units of insulin. In severe cases several liters of plasma may be needed and the amount should be calculated by two methods devised by the author (1941, 1942 and 1943). To perform such a calculation once is not enough any more than to give one dose of insulin is sufficient to last a diabetic patient several days. In a severe burn plasma tends continuously to leak out of the damaged blood vessels for at least thirty six hours. In severe cases this loss may be over 500 cc. of plasma per hour and may continue at this rate for several hours. The administration of plasma has nothing to do with stopping this loss; it merely affords a replacement of that amount which is already deficient. Hence, in severe burns there may be a necessity for *repeated* observation of the blood concentration for example every two hours the first twelve hours, every four hours the second twelve hours and every six hours the third twelve hours. In each instance the indicated amount of plasma should be given. After the first thirty six hours death in burns is usually due to other causes than shock.

CALCULATION OF PLASMA DOSAGE—The author's formulas for the calculation of plasma dosage are as follows

1 *Hospital Method*—When laboratory facilities are available the simplest technic is to give 100 cc of plasma for every point the hematocrit is above the normal of 45. This method applies to adults; for children the amount of plasma is calculated proportionately according to body weight with the average adult weight set as 70 kilograms. If the plasma protein level is below normal this method gives too low a value. In such a case an additional 25 per cent of the calculated amount of plasma should be added for every gram the protein level is below 6 gm per 100 cc. When hemoglobin determinations rather than hematocrit readings are available 50 cc of plasma should be given for every point the hemoglobin is above the normal of 100. Likewise when red cell counts are the basis for calculation 50 cc of plasma should be given for every 100 000 the red count exceeds the normal of 5 000 000.

2 *First Aid Method*—In some emergencies plasma is available but laboratory facilities for calculating its dosage are not. In such instances a knowledge of the Berkow formula for calculating relative skin area has a direct application. With a known extent of skin area burned the simplest technic is to give 50 cc of plasma for every per cent of the body surface affected by a deep (blistering) burn. This method roughly gives the entire amount of plasma that will be necessary; this amount should not be administered all at once but according to the following schedule: one third the first two hours, one third the next four hours and one third the next six hours.

II LOCAL CARE OF THE BURN WOUND

Local care of the burn wound should be carefully correlated with the general management of the burned patient. Local care is difficult and requires meticulous technic so that it almost might be said that more important than the treatment which is chosen is the way in which it is applied. In the author's recent book on burns (1942) over eighty methods of local treatment were listed, testifying to the confusion that exists in this branch of therapy. In general most of the popular remedies can be classified under three heads:

- 1 *Tanning Agents* Tannic acid spray tannic acid jelly tannic acid baths tannic acid silver nitrate gentian violet, gentian violet silver nitrate triple dye ferric chloride brilliant green sulfadiazine spray etc
 - 2 *Washing Methods* Saline baths water baths Bunvan envelopes saline dressings etc
 - 3 *Ointments* Vaseline gauze scarlet red paraffin spray etc
- These may be applied with or without the use of sulfonamides or of pressure

So many of these remedies have been discussed in previous articles (Hamilton 1942 Harkins 1938 1942 McClure and Lam 1943, and others) that only five of them will be considered in detail here. This does not mean that certain other methods are not equally deserving of consideration as are some of those discussed but merely that all of the latter are the focus of attention at the present time.

1 Tannic Acid Silver Nitrate

Introduced by Bettman (1935) this method has the advantage of quick tanning and simplicity. The speed of action has long been recognized as a valuable means of stopping early fluid loss but its advantage in preventing the absorption of tannic acid products (tannates²) has only recently been recognized. This method produces a tan in a matter of minutes or even seconds thus having an especial advantage in wartime.

Those clinics which have used tannic acid jelly or baths over a long period of time for the treatment of major burns have reported an unusually high incidence of fatal *liver necrosis*. This may be because the absorption of tannic acid or its products is increased by the prolonged exposure to the substance in a moist form. Liver necrosis following burns was first recognized by Wilson, Macgregor and Stewart (1938). Other papers on this complication appeared by Belt (1939) McClure and Lam (1940) Buis and Hartman (1941) Boyce (1942) Wells Humphrey, and Coll (1942) and by Erb Morgan and Farmer (1943). Wells and his associates (*loc cit*) were the first to demonstrate that tannic acid played a role in the production of this syndrome. Forbes and Evans (1943) in experimental observations on rats using tannic acid subcutaneously found definite evidence for a hepatotoxic action of this substance.

On the other hand tannic acid and silver nitrate in combination seem to give little danger of absorption if not repeatedly and unnecessarily applied. The use of tannic acid jelly in the treatment of major burns has proved dangerous but tannic acid silver nitrate has given good results in the hands of those accustomed to its use (Penberthy and Weller 1939 Glover and Sydow 1941 and Farmer 1943)

2 Sulfadiazine Spray

This method of burn treatment was first introduced by Pickrell (1941) who used a 3 per cent solution of sulfadiazine in 8 per cent triethanolamine. Such a solution is almost odorless, has a bitter taste, does not stain and will not injure skin, mucous membranes or granulating surfaces. Pickrell reported good results in the treatment of fifteen major and 100 minor burns and stated: "We feel confident that regardless of how often the spray is applied, it does not coagulate or destroy normal tissue." The method of applying the solution is easily remembered: it being sprayed on every hour the first day, every two hours the second day, every three hours the third day and every four hours the fourth day. Observation of the blood sulfadiazine level attained is desirable.

Coloviras West and Armour (1942) reported on a series of burns treated by the use of the sulfadiazine spray. They concluded that the *advantages* of the method are: 1 The diazine spray has a high chemotherapeutic activity against both gram positive and gram negative organisms commonly infecting burns. 2 Ease of management is a conspicuous feature of the method. 3 Pain is relieved early in the treatment (15 minutes). 4 The eschar, a solidification of the vehicle rather than a precipitation of surface proteins, can be adjusted to any depth by varying the amount of spray applied and the resultant eschar is soft, pliable, translucent and not easily cracked. 5 Its use in burns of the face is not contraindicated in the least. 6 There is a low toxicity with use of the drug. 7 As a result the length of hospitalization might be shortened. On the other hand Coloviras West and Armour list the following *disadvantages* of the method: 1 The eschar is relatively slowly formed. 2 Possible toxic reaction with use of the drug in cases involving large areas of body surface. 3 As with other eschar

methods of treatment grafting is impeded Rothman, Tamerin and Bullock (1942) reported favorably on the use of a 2.5 per cent solution of sulfadiazine in 8 per cent triethanolamine Pickrell himself (1942) recognized certain of the disadvantages of the aqueous sulfadiazine solution, stating 'However this solution, when used on burned patients had several disadvantages. Since it was an aqueous solution the drying time was slow as compared with other forms of treatment and the film formed over the burned surface was thin and fragile

3 Sulfonamide Film

In an attempt to overcome the objections to the aqueous solution, Pickrell (1942) added methyl cellulose. In some cases the solution was sprayed directly on the burn wound in others a preformed film was applied. The preformed films discussed by Pickrell in this paper were made in the following manner.

An emulsion is prepared containing 3 per cent sulfadiazine or 3 per cent sulfanilamide 2.5 per cent methyl cellulose (Dow methocel—15 centipoise) 3 per cent triethanolamine and 0.5 per cent sorbitol with 50 per cent alcohol or acetone added to make 100 cc. The resulting emulsion is sprayed on a smooth horizontal glass surface allowed to dry, cut into sheets of the desired size and sterilized by dry heat. The film contains about 35 to 50 per cent sulfonamide. Pickrell used these films on burns in a series of about fifty patients. Preliminary cleansing of the burned area was followed by the application of the film covered in turn by a gauze pressure dressing. This dressing is left in place for several days. Later Pickrell (1943) used a fluid sulfadiazine film of the following composition:

- 7 Sulfadiazine
- 77 2-amino-2-methyl-1,3-propanediol
- 7.5 Methocel (25 cps)
- 0.1 Aerosol OT
- 0.1 Sodium benzoate
- Water to make 100 cc

A similar solution can also be made without the propanediol. Other films are being experimented upon by this author. Adams and Crawford (1942) reported that they have been using some what similar films.

Clark Strakosch and Leven (1942) after testing the action of sulfonamide films in ten cases of burns seen at the Ancker Hospital St. Paul decided to impregnate the films in various cloth fabrics. These authors used such prefabricated escharotic bandages in a series of experimental burns on rabbits. They discarded the ordinary films not containing cloth in favor of the above described bandages with embedded fabrics since the films without such fabrics tore too easily when wet dissolved too rapidly on the wounds necessitating frequent renewals and were not as flexible and adherent.

Andrus, Nickel and Schmelkes (1943) treated a series of ten burns five of which were severe enough to cause the patient to be hospitalized with buffered sulfanilamide film. They stated: "Apart from the good clinical results obtained in these ten cases the obvious advantages of this form of treatment are its ease and rapidity of application. Given the sudden incidence of a large number of burns (on board a ship for instance) this membrane can be applied quickly and easily and can be held in the proper position by a dry dressing placed over it. The membrane can be applied by any one trained in first aid. It obviates the necessity of applying ointments, salve or jellies. If it is desirable to remove the membrane it need merely be moistened with sterile water or solution of sodium chloride. Another practical advantage of this medication is that the material used for it is light and not bulky. A few grams of the membrane replaces bulky and heavy containers. This aspect may be of prominent importance when shipping space is scarce."

4. Paraffin Spray

This method of treatment was introduced by Barthe de Sandfort just a few months before World War I. Possibly because of the timeliness of the report this was a favorite during that war. Later it became less popular although a few men such as Sherman (1938) continued this treatment and were well satisfied with the results.

Recently Pendleton (1942, 1943) of the U. S. Navy has revived the use of the paraffin spray modifying it to contain sulfanilamide powder and cod liver oil. The formula of Pendleton's open air paraffin wax spray treatment for all types of burns is as follows:

R. Paraffin wax	670 gm
Petrolatum	250 gm
Liquid petrolatum (heavy)	150 gm
Cod liver oil	50 cc
Sulfanilamide powder	50 gm
Menthol	
Camphor aa	1 gm
Oil of eucalyptus	1 cc

This mixture is warmed usually over a 25-watt globe and sprayed directly over all freshly burned surfaces. Only a thin layer is applied not the thick carapace that was used with the original ambrine treatment. No dressings are applied over the wax. Portions of it may be removed and a new coating re-applied. Two special features of the after care as used by Pendleton seem to be of especial value. The first of these is the use of a chair in a bathtub combined with cleansing the burn with a hand bath spray for fairly ill patients. This method obviates the contamination of clean areas such as occurs during a tub bath. The second is the use of the shower bath in all cases in which this is at all feasible.

5 Ointment Gauze—Pressure Dressings (Koch Method)

Ointments have been applied to burns for a long time but their combination with sulfonamides or pressure has been much more recent. Brown and Blair (1935) had already described the importance of vaseline gauze pressure dressings in the preparation of granulating surfaces for grafting while Koch himself and others had used such a method for dressing wounds or grafts for some time. An application of this principle to burns themselves was made by Koch (1941). The method essentially involves three steps.

First Step *Washing of the burn wound* This should be done with white soap, water and soft cotton cloths or absorbent cotton. The technic requires extreme gentleness and working under sterile precautions including the use of masks and gowns as well as aseptic technic. This cleansing should be thorough but gentle enough so that general anesthesia is not necessary.

Second Step *Application of a bland ointment gauze* In most cases a fine mesh gauze is used which is impregnated with one of the following substances

Zeroform gauze (Koch 1942)

Vaseline gauze (Siler and Reid 1942)

Twenty per cent sulfathiazole emulsion in aquaphor gauze
(Dragstedt 1941 Allen Owens Ivans and Dragstedt 1942)

Sulfathiazole emulsion (M G H formula) (Gurd 1947)

Scarlet red gauze (Romence 1942)

Boric acid ointment gauze (Churchill 1942)

It would seem that the exact nature of this gauze is of secondary importance to the carrying out of the other principles involved in the method

Third Step Application and maintenance of uniform pressure This is possibly the most important feature of the technique. A buffer and distributor of pressure is essential and for this purpose generous amounts of sterile mechanics waste are needed. This material is cheaper than sea or rubber sponges. Over the entire dressing elastic bandage is applied. These bandages may be used more than once but in some cases elastic adhesive is preferable as it more certainly prevents slipping. Such a dressing should not be changed for from seven to twelve or even fourteen days. In some instances splints afford additional immobilization.

The Koch method has been described by Siler (1941) Allen and Koch (1947) Siler and Reid (1942) and others and by Gurd and associates (1942) in a modified form. Not only is the local wound well dressed and protected from infection but the action of the pressure cuts down the plasma loss. This prevention of plasma loss includes partly that usually occurring as weeping from the surface but especially that into the damaged tissues.

Practically all those who have used this method have been favorably impressed with the results. Using a standard depth dermatome graft donor site in human beings as the test objects, Hirshfeld, Pilling and Maun (1943) found that donor sites heal more quickly with less discomfort when treated by vaseline gauze than when treated by tannic acid and that tanning agents produce extensive tissue damage to the dermis to form the eschar while vaseline gauze produces a minimal damage. Meyer and Gradman (1943) compared the results with sulfadiazine spray (3 to 3.5 per cent in 8 per cent triethanolamine) and with nonadherent pressure dressings (Koch method) on

equal portions of the burns of five patients. The results with the nonadherent pressure dressings were almost uniformly better. It would seem that one of the advantages of the method is that any suitable coating could be applied to the burn under the pressure dressing. This might include the sulfonamide films or even paraffin wax. But in general the use of a protective covering, pressure and immobilization are the essential features of the method.

III EARLY PLASTIC CARE OF GRANULATING SURFACES

Such care involves especially the use of a suitable definitive treatment for the original burn so that the first grafting will in general not be delayed beyond the fifth week. Third degree burns are by definition those which produce granulating surfaces. Until these surfaces are healed the patient is the subject of continued hemorrhage and plasma loss; he is in constant danger of all sorts of septic complications and the longer the granulations remain the worse will be his cosmetic and functional deformity. In all cases the so called principle of closure of the wound should be carried out. As long as a granulating area is present the burn is not healed and the wound is not closed. As already stated in the realm of abdominal surgery one would not think of attempting a cholecystectomy if he did not know how to close the abdomen. Similarly, no physician should treat severe burns who does not know when and how to graft skin upon the resulting granulating surfaces. Any burn granulating surface more than 2 inches in diameter or which appears to require more than three additional weeks to heal should be skin grafted. Skin grafting of burns is most simply done when using the Padgett Hood dermatome. In the author's service at the Henry Ford Hospital over 150 dermatome grafts have been taken during the past three years for one purpose or another, a good share of them for skin grafting of burns. The use of the dermatome is shown in Figures 341 to 342.

The use of vaseline gauze and pressure dressings is not confined to the early care of burns. This method not only serves very well to prepare granulations for grafting but also with practically no changes acts as the ideal dressing for the grafts during the all important first few days after their application.



Fig 341—A Full size derm tom graft and free donor area Patient E S adult male grafting done 6 weeks after burn The graft was taken from the thigh at a depth of 0.017 in h s B Application of derm tom grafts to right axilla of same patient



A

B

C

Fig 347—A Left axillary contracture existing four months after third degree burn of left side and arm Patient M A aged two years Three previous graftings were done and it is of interest that the site of the contracture was spared by the burn This made the subsequent plastic procedure much easier B Result nine days after combined Z plasty and insertion of dermatome grafts at ends of Z Burn received on 5/5/42 Z plasty on 10/15/42 C Final result six weeks later on December 7 1942

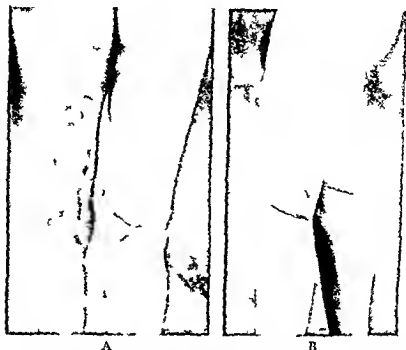


Fig 343—A Rear view of contractures of popliteal fossae. This man E. E. aged thirty-four was burned in childhood twenty-eight years before. No skin grafting procedure was ever done and the patient was never able to extend his leg fully. This is an example of a neglected burn. B Lateral view of same.



Fig 344—Scar removed from left popliteal fossa of E. E. A similar scar was excised on the right side. These scars were almost 8 mm thick in places and were quite inelastic. Removal was carried on down to normal fat beneath.

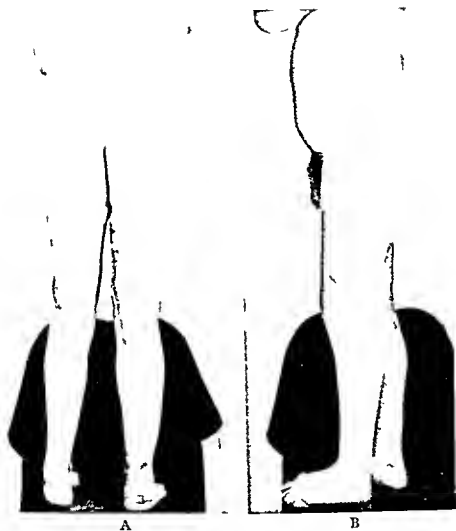


Fig 345—*A* Rear view of result after dermatome grafts. The scar was removed and a dermatome graft was applied to the left popliteal fossa on 5/7/47 and a similar operation done on the right side on 5/9/47. *B* Side view of same.



Fig 346—A Dorsal view of burned hands of I.P. as seen on October 10, 1942 six months after burn. Nippon skin grafting was performed. The original treatment given to patient a male aged thirty-three years in another hospital included the local application of ferric chloride. The tarsus at the time of the above picture had a marked inflammation in the center of the fingers due to the thickness and elasticity of the scar. Such a burn is quite similar to the so-called "a" burn which is common in the present war.

B Patterns used in secondary skin grafting on right hand. Several skin grafting procedures were done but the above picture depicts the third such

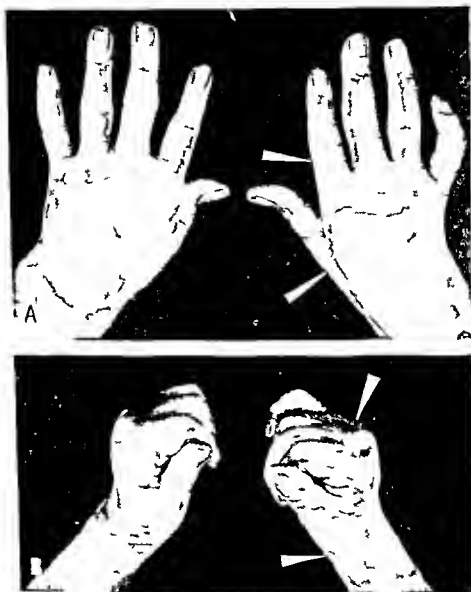


Fig 347—A Result in case of I P on February 19 two months later The arrows denote the two grafts described in Fig 346 B B Another view of same

which involved excision of the scar and application of dermatome grafts to the dorsum of the index middle and ring fingers of the right hand and the lateral surface of the right thumb and wrist These grafts were taken at a depth of about 0.018 inches (a) Scar removed from three fingers (b) Scar removed from thumb and wrist (a') Gauze pattern of resultant raw area on fingers (b') Gauze pattern of resultant raw area on thumb and wrist (a'') Gauze pattern of size of donor area after removal of dermatome graft for fingers (b'') Same for thumb and wrist Top right excess donor skin trimmed away



Fig. 348.—*A* Right sided skin shortening in a girl of sixteen years. This I. D. M. M. aged eighteen years was burned for the first time at the age of four years. Skin grafting was done ten years ago but when the above picture was taken a raw area was still present over the right thigh. This is an example of a neglected burn.

B Result seen months later after four grafting procedures. The girl has been practically repaired and may need further treatment. The most remarkable feature of the result however is that the distance *ab* which now measures 18 inches was formerly occupied by the two segments of scar skin between the three skin grafts *A*, *B*, and *C*. This old scar skin measures only 8 inches. Thus 8 inches of skin was occupying the distance now occupied by 18 inches. No scar has been excised; the three elliptical grafts *A*, *B*, and *C* merely fill in the relaxing incisions.



Fig 349—A Severe third degree burn in old lady aged sixty four years. This burn was received on 4/4/47 and involved practically the entire circumference of the trunk and both arms. Immediate treatment included butesine picate ointment in another hospital.

B Donor areas on lower legs. Because the thighs had been utilized by four previous grafting procedures on 6/70/47 the calves and shins were used for taking six dermatome grafts, four of which are seen in the above picture, the other two being on the posterior surface.

C Final result six and one half months after burn. Seven skin grafting procedures were performed.

SPECIAL BURNS

A few special remarks on two common types of chemical war burns may be apropos at this time. This is not because these burns are of especial frequency although neither of them are rare but because of new ideas concerning their management. We will now consider first magnesium burns and second phosphorus burns.

Magnesium Burns

These represent a type of burn especially common among war workers in factories and among civilians struck by incendiary bombs. Magnesium is classified as a light metal (as are aluminum, beryllium and others) and the resultant burns are entirely different from those caused by heavy metals (iron, copper, zinc and their alloys). Burns caused by heavy metals heal rapidly and their extent is dependent upon the amount of tissue destroyed by the heat of the metal at the time of the burn. Magnesium burns on the other hand produce ulcers which even though originally small may gradually enlarge to form extensive lesions over a period of weeks. According to Wilson and Egeberg (1947) the floor of the ulcer is irregular and made up of several reddish brown small raised areas called by some writers granulomatous tubercles. The edges are not punched out and they are not very painful. McCord, Prendergast, Meek and Harrold (1942) performed experiments on white rats and rabbits introducing magnesium alloy. They concluded: "Light metals and particularly magnesium on contact with aqueous fluids liberate a gas both in the body and in vitro." Puncture wounds from metallic magnesium or some alloys may because of the phenomenon just mentioned lead to injury of a type more severe than ordinary foreign body injuries. Under experimental conditions less than 100 mgms of metallic magnesium produced within 24-36 hours single or multilocular gaseous tumors yielding on puncture near to 5 cubic centimeters of gas. Initially the gas is believed to be hydrogen but through diffusion and admixture other gases come to dominate the chemical analysis. The clinical picture is one of chemical gas gangrene or necrosis. Actual human experience in the United States is limited or at least not known to have been published but in case of puncture wounds unfa-

ingly it becomes the duty of the attending physician to remove all portions of the gas liberating magnesium

Wilson and Egeberg (1942) based their clinical advice on the above cited work of McCord and his associates and pointed out that at first much of the magnesium is on rather than beneath the skin. Hence scraping the outer layers of skin off under novocain anesthesia in cases of superficial magnesium burns represents adequate treatment. These authors point out that in some cases the magnesium particles may be disseminated by way of the lymphatic system, thus they saw one man with a burn of the first joint of the right thumb in two or three weeks a lesion developed on the midforearm.

Although none of these authors suggest it the probability presents itself that magnesium burns when treated in a well equipped hospital offer an ideal application in properly selected cases for the method of primary debridement with immediate skin grafting. Especially is this true since most magnesium burns are small thus in Wilson and Egeberg's series the largest burn was 2 inches in diameter.

Phosphorus Burns

The subject of phosphorus burns has been covered in the author's recent book on burns (1942). The review by Rabinowitch (1943) represents the recent advice of the Canadian Government and is an excellent presentation of the subject. Rabinowitch divides the treatment as follows:

(a) *First Aid Treatment*—This is based on the fact that phosphorus gives off phosphoric acid while it burns and the phosphoric acid causes the skin to burn. Advantage is taken of the interaction between copper and phosphorus to form non-igniting black copper phosphide. The skin is flushed with water, the particles of phosphorus picked out as thoroughly as possible and if available a warm solution of baking soda applied (The water dilutes the phosphoric acid, the alkali neutralizes it). Finally an application of 1 per cent copper sulfate solution will precipitate the small particles of phosphorus or serve to make more visible the large particles so that they can be more easily removed. Copper sulfate does not destroy large particles of phosphorus. Oils and grease should not be applied at this stage because if not all the phosphorus is removed the oil

will dissolve it and facilitate its penetration into deeper structures

(b) *Medical Treatment*—This depends on the availability of the different inactivating agents and includes the use of (1) sodium bicarbonate or dilute carbonate (2) alkaline powder mixture (magnesium oxide [heavy] 10 parts borax 5 parts and sodium bicarbonate 85 parts) (3) copper sulfate solution and finally (4) oil soluble copper preparation. This preparation developed by the Imperial Chemical Industries Ltd. has the following composition:

R. Copper oleate	25 gm
Trichlorethylene	35 gm
Turkey red oil	25 gm
Surgical spirit	15 gm

The copper oleate is dissolved in the trichloroethylene. The Turkey red oil (sulfonated castor oil 70 per cent ammonia finished) is then incorporated into the mixture and the alcohol (denatured alcohol unpurified containing $\frac{1}{4}$ ounce of castor oil and 1.6 drams boric acid to a pint) is added to the final mixture. The final solution is deep blue green in color and perfectly homogeneous.

This solution is applied and then after thorough inactivation of the phosphorus the emulsion is washed away with tepid water. Sodium bicarbonate paste is applied and finally the definitive treatment of the burn performed. Tannic acid seals in the acid products and is not suitable, but bland ointment dressings work well.

In Great Britain the Ministry of Health (1943) issued instructions for the care of phosphorus burns. While these seem more elementary than those of Rabinowitch quoted above they will be listed at this time:

TREATMENT OF PHOSPHORUS BURNS AS RECOMMENDED BY THE MINISTRY OF HEALTH GREAT BRITAIN

At the Incident

1. Apply water immediately to the affected part to extinguish any burning phosphorus and to keep the area moist (water from the water bottle may be used for this purpose).
2. Apply a clean mines dressing or clean lint or clean cloth soaked in water over the burn. Whatever dressing is used it must be kept wet as otherwise it may burst into flame.

- 3 With the wet dressing in place the casualty if a sitting case or able to walk should be conveyed or directed *at once* to the nearest first aid post or hospital for further treatment
- 4 Stretcher cases must be sent direct to a hospital with the least possible delay To ensure immediate attention at the hospital these casualties must be labelled and the label marked with a P The attention of the ambulance attendant must be drawn to the case

At the First aid Post or Hospital

- 1 Immerse the affected part in water or if sufficient water is not available apply a moist dressing soaked in water Keep the dressing wet until the following treatment can be applied
 - 2 Thoroughly flood and wash the affected area with bicarbonate of soda solution (roughly two tablespoonfuls of the powder to a pint of cold tap water) Pick off with forceps any obvious particles of phosphorus disclosed by examination in the dark (phosphorescence)
 - 3 Swab the affected area with a 1 per cent solution of copper sulfate which will coat any remaining phosphorus particles with a dark deposit of copper phosphide Remove with forceps or gauze as much of this as is possible without damaging the tissues
 - 4 Immerse the affected area in the bicarbonate of soda solution for a prolonged period The duration of this soaking depends upon the size and depth of the burn—i.e. small burns one half hour large burns one to two hours If immersion is impossible keep the sterile dressing repeatedly wetted with the bicarbonate solution
 - 5 Finally re examine the burn in the dark for phosphorescence If this is not present, dress as for an ordinary burn If there is still any doubt about the presence of phosphorus dress the burn four hourly with lint soaked in sodium bicarbonate solution (2 tablespoonfuls to the pint of water) and retain the patient (if at a first aid post)
- No oils or greasy dressings and no tannic acid triple dye or brilliant green must be used in the treatment of phosphorus burns *so long as any trace of phosphorus remains in the tissues* Oils and greases are solvents of phosphorus and their use while it is present will cause risk of poisoning from absorption

CONCLUSIONS

1 Burn treatment should be a continuous process with correlation of the general, local and skin grafting phases

2 *General Treatment*—The control of shock and of sepsis are most important. The chief item in the control of burn shock is the administration of adequate doses of plasma. The necessary dosage of plasma for an average sized adult can best be calculated by giving 100 cc of plasma for every point the hematocrit exceeds the normal level of 45. In serious cases repeated calculations must be made and the required dosages given at short intervals during the first thirty-six hours following the burn.

3 *Local Treatment*—No matter what method is chosen the application of sound surgical principles and meticulous technique are essential.

4 *Early Plastic Care*—In all third degree burns the resulting granulating surfaces should be skin grafted as early as possible. The first grafting of skin in a burn which requires any at all should seldom be postponed beyond the twenty-eighth day.

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TECHNIC OF GASTRIC RESECTION FOR CARCINOMA*

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LATER diagnoses and more radical operations are the only methods of increasing the present day deplorably small number of five year survivals following resection of gastric carcinoma. A study of the case histories of our own patients who are alive and well five years and more after operation for stomach cancer brings out one point of great practical importance, viz the ulcer cancer relationship. Fully 75 per cent of the five year survivals occurred in the group of patients in which the gastroenterologist, the roentgenologist and the surgeon were unable to make an all out diagnosis of carcinoma. It is obvious then that a more radical approach to gastric ulcer will increase the number of patients in this group. Some of the operations now performed for gastric carcinoma are too limited in their scope to be designated as radical procedures. An adequate operation for cancer in any location implies removal of the growth and a generous margin of healthy tissue together with as much of the lymph drainage vessels and nodes as is practicable. Many partial gastrectomies for carcinoma fall short of this goal by failure to remove all of the great omentum and by failure to ligate the right gastric epiploic and left gastric arteries at their sources of origin. These technical points will be considered as the various steps are outlined.

PREOPERATIVE PREPARATION

The importance of adequate preparation for operation can not be overstressed. Restoration of water and electrolyte balance, correction of existing anemia, Vitamin C administration and protection of the liver by Ravdin's¹ high protein, high carbohydrate, low fat diet are essential features of the preopera-

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tive regimen. Mechanical cleansing of the stomach by repeated gastric lavage with bicarbonate of soda solution is necessary to remove the excessive mucous secretion produced by the ever present chronic gastritis. This mucus can be removed only by the large gastric tube since the lumen of the Levin tube is too small. In an effort to cut down the number of organisms present the stomach is washed out with half strength aqueous solution of hexyl chloro m cresol the night before operation and just before the patient is taken to the operating room 700 cc of the same solution is introduced into the stomach through the indwelling Levin tube. The tube is clamped off and not released until actual manipulation of the stomach takes place. The antiseptic is then removed by suction. Intravenous 5 per cent glucose solution or pectin³ is routinely administered as a supportive measure. Blood or plasma is given during the operation if the systolic blood pressure falls below 100 otherwise the transfusion is given after the patient is returned to bed.

ANESTHESIA

Spinal anesthesia with nupercaine 1:1500 solution administered by the Jones⁴ technique maintains perfect relaxation for two hours or more. It is definitely the anesthetic of choice provided there is no contraindication to the use of spinal anesthesia. Local block or infiltration with 0.5 per cent novocain solution supplemented by inhalation gas or intravenous anesthesia is useful in poor risk patients.

OPERATIVE STEPS

1 *Incision*—The midline incision through the linea alba and extending from the umbilicus to the tip of the sternum provides adequate exposure. The abdomen is quickly entered through an avascular area and no tissue spaces are opened as with the paramedian incisions. Postoperative hernia may be prevented by a careful fascia to fascia approximation with interrupted silk sutures. If this incision is utilized it is absolutely necessary to use nonabsorbable sutures for there will be a high incidence of incisional hernia if corgut sutures are employed.

2 *Exploration*—The abdomen opened the hand is passed into the pelvis seeking evidence of malignant peritoneal implantation. Next the liver is palpated for the presence of metastases. Finally the stomach is investigated for fixation of the

tumor Invasion of either spleen pancreas, or transverse colon alone should not of themselves rule out operation Involvement of the mesocolon may necessitate resection of the transverse colon because of damage to the middle colic artery Prepyloric tumors invading the head of the pancreas and encroaching on the duodenum make up most of the cases of borderline operability Even if it is obvious that a cure is improbable operation should be carried out to rid the patients of their fungating primary growths and above all to relieve them of the distressing gastritis that accompanies malignant tumors of the stomach

3 *Removal of Great Omentum*—The entire great omentum is easily detached from the transverse colon by sharp dissection in an avascular plane The great omentum has no primary anatomic connections with the colon The attachment is acquired during the later stages of prenatal development thus accounting for the absence of blood vessels Once the cleavage plane is entered the colon is easily separated until the gastrocolic portion of the omentum is entirely freed and the whole of the great omentum hangs free from the greater curvature of the stomach As the posterosuperior margin of the colon is reached the superior leaf of the transverse mesocolon should also be stripped upwards care being taken not to injure the trunk and branches of the middle colic artery The rationale of removal of the great omentum and upper leaf of mesocolon is that malignant cells implanted from the gastric tumor such as those that reach the pelvis may be picked up by them The resection of these structures therefore should be part of a radical operation designed for the eradication of gastric carcinoma

4 *Ligation of the Greater Curvature Vessels*—A Left gastro epiploic artery at the extreme left margin of the greater curvature is a relatively small branch of the splenic artery It should be sectioned and ligated by transfixion as far to the left as possible

B The right gastro epiploic artery is a vessel of extreme importance The lymph vessels draining the entire greater curvature of the stomach accompany the main trunk Enlarged lymph nodes in both ulcer and carcinoma are constantly present although in carcinoma enlargement is not necessarily due to invasion of malignant cells These nodes can be removed only by tying the artery close to its origin from the gastro

duodenal artery in the angle between the duodenum and the head of the pancreas a step that is easily carried out if the upper leaf of the mesocolon has been removed. The origin of the right gastro epiploic and middle colic arteries are relatively closely approximated so that great care must be taken not to confuse these arteries.

5 *Ligation of Right Gastric Artery*—The right gastric artery like the left gastro epiploic is a small vessel. Section and

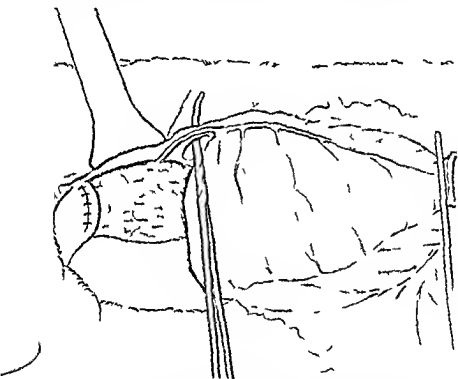


Fig. 350—Ligation of the left gastric artery posteriorly after the pylorus is sectioned and the stomach is drawn over the left.

ligation of this artery with the first portion of the lesser omentum aids in freeing the duodenum.

6 *Management of the Duodenum*—Mobilization of the duodenum by incising the peritoneum and fascia propria along its outer side allows the pylorus to be brought up into the wound. The duodenum is cut across just beyond the pylorus except in those rare instances of encroachment of the growth when a portion of the duodenum must be sacrificed. The cut end of the

duodenum and stomach are controlled with crushing clamps. The duodenum is closed by any of the accepted methods⁵ using fine silk or any of the nonabsorbable sutures for at least one of the layers.

7 *Ligation of Left Gastric Artery*—The left gastric artery should be ligated close to its point of origin from the hepatic artery just as it emerges from the upper border of the pancreas. The artery is enveloped in fibro fatty tissue the so called gastropancreatic omentum⁶ which extends from the upper border of the pancreas to fuse with the structure of the gastrohepatic omentum near the gastro esophageal juncture. The left gastric like the right gastro epiploic artery is surrounded by the lymph vessels and nodes draining the lesser curvature. Ligation of this vessel close to the pancreas achieves a two fold purpose. First it allows for removal of all this lymph drainage area and second it completes mobilization of the stomach. The actual ligation is carried out by turning the stomach over to the left (Fig 350). Tension on the gastropancreatic omentum causes the artery to stand out so that recognition is easy. The surrounding fat and lymph structures are stripped upwards to allow placing of the clamps close to the pancreas. Sectioning of the artery between the clamps completely mobilizes the stomach. The stump of the artery is secured by transfixion with a medium silk suture.

8 *Removal of the Lesser Omentum*—The right and middle portions of the lesser omentum are of flimsy structure and are easily separated from the liver by blunt gauze dissection but the upper portion near the gastro esophageal junction is more fibrous and contains some blood vessels. The two leaves of the omentum at this point are separated by insinuating the left fore finger between them and first the anterior and then the posterior leaf is doubly clamped and cut across. The portion of omentum in the grasp of the upper clamps is tied and that in the grasp of the lower clamps is stripped down the lesser curvature until the junction of the upper and middle third of the stomach is reached. In this manner the whole of the lesser omentum and its contained left gastric artery together with lymph nodes and vessels is removed en masse.

9 *Section of the Stomach*—Removal of from three quarters to four fifths of the stomach is imperative because of ligation of fully 75 per cent of the blood supply. The only remaining

arteries are the short gastric a minor portion of the left gastro epiploic and some of the small esophageal arteries Two Ochsner Kocher clamps are placed on the stomach at the point of section One applied from the greater curvature side takes a full bite while that applied from the lesser curvature side grasps only enough tissue to enable the point of the two clamps to meet A second paid of clamps is applied parallel to and 1 cm

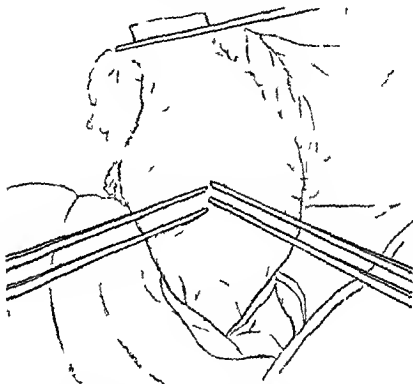


Fig 351—Plac ment of Ochsner Kocher cl mps on the stomal at a 45 degree angle

distal to the first Placing the clamps to meet at an angle of 45 degrees (Fig 351) produces much the same effect as the more cumbersome Schoemaker clamp in that after closure of the upper part of the stomach it allows the portion in the grasp of the lower clamp to be drawn out in the form of a tube (Fig 352) The stomach is cut across above the proximal clamps leaving a small fringe of tissue to prevent slipping of the relatively weak Ochsner Kocher clamps The upper clamp is removed

and the edges of this portion of the stomach are approximated with Allis clamps

Closure is effected by an interlocking catgut suture on an atraumatic needle commencing at the point where the clamps meet, carried up towards the lesser curvature and then back to the starting point as a Lembert suture. The line of closure is reinforced with interrupted sutures of fine silk (Fig 352)

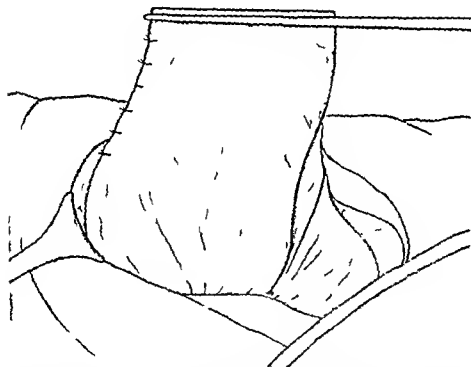


Fig 352—Closure of the upper half of the stomach allows the lower portion to be drawn out in the form of a tube. This maneuver facilitates anastomosis but creates the false impression that a high resection has not been done

Starting the closure at the lower end rather than at the lesser curvature gives better control of the segment and is of especial value in high resections. When closure is complete it will be found that the remaining stomach is drawn out into a tubelike formation which may give the impression that a limited resection has been carried out. The increased mobility and consequent ease of anastomosis to the jejunum are striking features

of this modification of the usual method of sectioning the stomach

10 *Gastrojejunal Anastomosis*—An isoperistaltic retrocolic type of anastomosis is routinely done though if the mesocolon is foreshortened a high resection is performed or if there is local extension of the disease an antecolic union is effected. The posterior serosal suture is of running silk (Fig 353). The inner suture is continuous interlocking No 00 chromic catgut on

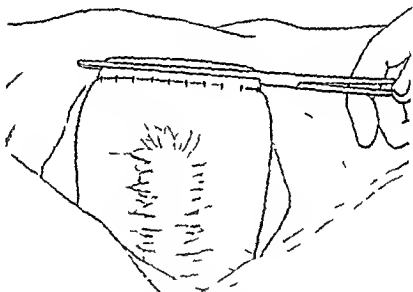


Fig 353—An isoperistaltic retrocolic short loop type of gastrojejunal anastomosis

an atraumatic needle. These sutures begin at the midpoint of the posterior anastomotic line and are carried in both directions to meet at the midpoint anteriorly. A more effective choice of the angles can be done in this manner than when these sutures commence at the end of the line. The anterior suture line is reinforced with interrupted Lembert sutures of fine silk. Kinking of the jejunum at the greater curvature is avoided by infolding only a narrow strip of tissue and the dan

gerous upper angle is protected by inserting a purse string suture which embraces both the anterior and posterior walls of the stomach as well as the jejunum itself. The junction of jejunum to the stomach is then carried up toward the lesser curvature for 2 or 3 inches. The anastomotic rent is then drawn through the mesocolon so that it lies entirely in the infracolic compartment. The margins of the rent in the mesocolon are united to the stomach to prevent retraction and to guard against hernia.

11 *Closure of the Incision*—Drainage is used only when there is doubt regarding the security of the duodenal closure. The linea alba incision is closed by a fascia to fascia approximation with figure of 8 heavy silk sutures and the skin margins are approximated with interrupted fine silk suture.

POSTOPERATIVE CARE

If blood or plasma has not been necessary during the course of the operation it is routinely given after the patient is back in bed. The oxygen tent is used in all poor risk patients and when the respiratory rate is above 30. The patient is instructed to exercise the legs as soon as possible and is aided and encouraged to change position frequently. Water is given freely by mouth provided the suction is working. This apparatus requires constant supervision to keep the tube free of blood clots and mucus. The tube is kept in place for four days and is removed only when the four hour residue after clamping is less than 100 cc. Feeding by mouth is not begun until the fifth postoperative day. Nutrition meanwhile is maintained by 5 per cent glucose solution and intravenous amino acids.

SUMMARY AND CONCLUSIONS

1 A step by step description of the operation for gastric carcinoma as practiced at the Henry Ford Hospital is outlined.

2 The essential features of a radical operation for gastric carcinoma are believed to be (a) removal of the entire great omentum and superior leaf of the mesocolon and (b) ligation of the right gastro epiploic and left gastric arteries at the point of origin.

3 The necessity for a more radical approach in gastric ulcer is pointed out.

of this modification of the usual method of sectioning the stomach

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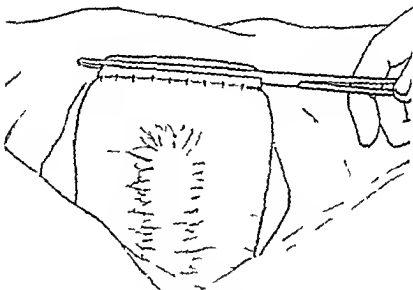


Fig. 353—An isoperistaltic retrocolic isoperistaltic type of gastrojejunal anastomosis.

an atraumatic needle. These sutures begin at the midpoint of the posterior anastomotic line and are carried in both directions to meet at the midpoint anteriorly. A more effective choice of the angles can be done in this manner than when these sutures commence at the end of the line. The anterior suture line is reinforced with interrupted Lembert sutures of fine silk. Hinking of the jejunum at the greater curvature is avoided by infolding only a narrow strip of tissue and the dan

MIKULICZ RESECTION FOR CARCINOMA OF THE RIGHT COLON*

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INTRODUCTION

THE Mikulicz type of operation for lesions involving the left colon has achieved almost universal acceptance. The safety factor of exteriorization is its chief appeal for in the hands of the average surgeon the mortality is lower than after any type of primary anastomosis. This plan of attack on lesions of the right colon has not received the recognition it merits though Lahey has repeatedly urged its adoption. Possibly this lack of popularity may be due in part to association with the totally inadequate original Mikulicz procedure. However the modern adaptation of the principle is just as radical as any other type of resection of the ileocecal segment of the bowel.

It should be emphasized that from a purely technical standpoint the Mikulicz method is easier to apply to the right colon than to the left. The original Mikulicz operation was designed for and applied to tumors involving the mobile portion of the sigmoid colon and here there are no technical problems. However many tumors involve the less mobile portions of the left colon where difficulties may be experienced in maintaining the integrity of the blood supply of the exteriorized loops owing to foreshortened mesenteries and variations in the vascular pattern. In the right colon none of these problems arises because mobilization of the whole ileocecal segment is a simple procedure which brings together the terminal ileum with its rich blood supply from the superior mesenteric artery and the mobile transverse colon with its adequate arterial ramifications. Moreover since the ileocolic and right colic arteries can be

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ligated close to their origins all the gland bearing area of the mesentery of the whole ileocecal segment may be removed even more completely than from any location in the left colon

Indications

There can be little question concerning the value of one stage resections in carcinoma of the right colon when the patient's general condition is good. The use of the long intestinal tube makes the operation safer since some of the strain is taken off the anastomotic suture line. The mortality from one stage operation is nearly always due to peritonitis from a leaking anastomosis or spillage at the time resection is done. Primary resections probably should be reserved for patients with early lesions discovered during routine check up or at abdominal exploration during the course of some other operation provided the resection is done at a later time.

The two stage procedure ileocolostomy followed by resection after an interval of two weeks undeniably has its place in the definitely poor risk group of patients since the complications of shock and peritonitis are both minimized by dividing the operative procedure.

The Milneiz plan of operation then has its greater application in the middle group of patients when the general condition is only fair because of loss of weight, anemia, mild obstruction and so forth. It is the procedure of choice when the ileum is dilated secondary to obstruction and when operation is carried out on an unprepared patient as for example when resection is performed following discovery of a tumor at the time of laparotomy for some other condition.

Advantages

- 1 Low mortality. The danger from peritonitis is minimized since the bowel and peritoneum are not opened at the same time.

- 2 It avoids the necessity for operative decompression in the presence of obstruction.

- 3 It may be used on the unprepared patient.

- 4 The chief advantage over the ordinary two stage procedure is that the tumor is removed at the first operation.

Disadvantages

1 *Temporary ileostomy* This presents little difficulty if steps are taken to protect the skin before the bowel is opened and continued until the enterocolostomy is closed. A paste consisting of powdered aluminum in a lanolin base is effective if it is continuously applied over a wide area. The spur crushing clamp can be applied as soon as the ileostomy functions satisfactorily with the result that intestinal continuity is partially restored by the time the patient is ready to leave the hospital.

2 *Two periods of hospitalization* The total hospital stay however, does not exceed that of the two stage method.

TECHNIC OF OPERATION

Preparation of Patient for Operation—A minimum hospitalization of five days is required for the correction of dehydration and anemia. During this period the life is protected by a

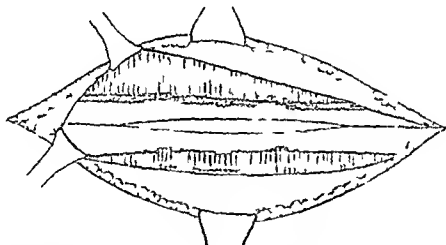


Fig. 354—Transverse incision across right rectus muscle at level of umbilicus.

diet high in carbohydrates and proteins and low in fat. Vitamin C is prescribed in daily dose of 200 mg. and the colon is cleansed by repeated enemas. The patient arrives in the operating room with a Miller Abbott tube well down the ileum and a catheter in the urinary bladder.

Anesthetic—Nupercaine 1:500 solution intraspinally is the anesthetic of choice though the operation can be done under

gas anesthesia combined with the infiltration of 0.5 per cent novocain solution or with local anesthesia alone if spinal anesthesia is contraindicated.

Incision—A transverse incision (Fig. 354) dividing the right rectus muscle just above the umbilicus gives better exposure, is easier to close and produces a more solid scar than the classical right rectus incision. Moreover, the wound can be closed about the extruded levels of ileum and transverse colon without any twisting or kinking of the intestine.

Exploration—After opening the abdomen the pelvis and liver are explored for evidence of metastasis. The tumor itself is investigated with regard to mobility, adherence to adjacent loops of small intestine and involvement of adjacent lymph nodes. Operation should not be denied the patient because of a single or doubtful liver metastasis, enlarged regional lymph nodes or the invasion of adjacent small intestine.

Operative Steps

1. *Division of Great and Gastrocolic Omentum*—Having decided to resect the ileocecal segment the surgeon commences by splitting the great omentum vertically so that the right half may be entirely removed. The gastrocolic omentum is then sectioned below the greater curvature to separate the right half of the transverse colon from the stomach, care being taken not to injure the right gastroepiploic artery.

2. *Mobilization of the Right Colon*—Mobilization of the cecum and ascending colon is accomplished by incising the peritoneum and transversalis fascia along the floor of the right colonic gutter. The incision should be carried medially below the tip of the cecum and around the curve of the hepatic flexure above. Except for small vessels in the phrenicocolic ligament this area is entirely avascular. The ascending colon with the tumor is now elevated into the wound and stripped medially by blunt gauze dissection until the midline is reached. Only two important structures, the duodenum and the ureter, are endangered during mobilization. The ureter, which is usually adherent to the peritoneum, must be carefully isolated; otherwise it may be cut during section of the mesentery. The retroperitoneal duodenum also must be identified and protected as the peritoneum is separated from its anterior surface.

3 *Section of Mesenteries of Terminal Ileum and of Mesocolon*—The lower 6 inches of ileum must be removed since its blood supply is derived from the ileocolic artery and not from the terminal radicles of the superior mesenteric artery. After the mesentery of the terminal ileum is sectioned and its vessels are ligated the stomach is retracted upwards and attention is directed to the vascular pattern of the right half of the transverse colon. The right branch of the middle colic artery arch

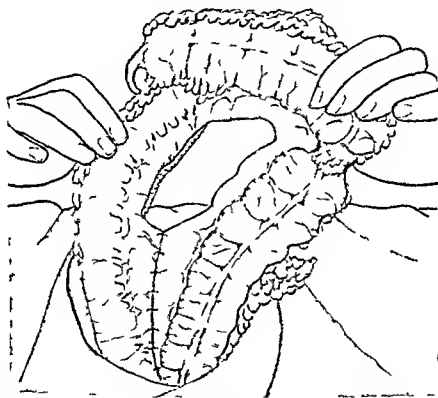


Fig 355—Mesentery of ileum sutured to mesocolon to prevent lateral herniation of small bowel

ing towards the hepatic flexure must be ligated but great care must be exercised not to damage the trunk or the left branch of this important vessel. The mesocolon is now divided during the course of which a few communicating vessels require tying.

4 *Ligation of Ileocolic and Right Colic Arteries*—The whole ileocecal segment of the bowel is now hinged on its mesentery and fixed in position only by the ileocolic artery and vein. Ligation of these vessels conveniently approached from the outer side should be carried out near their point of origin from the

trunk of the superior mesenteric artery in order to remove the accompanying lymph vessels and nodes. Mobilization is completed by tying the right colic artery and cutting the remaining mesentery of the segment close to the dorsal midline so that a radical removal of the lymphatic drainage is accomplished.

5 *Exteriorization*—The completely mobilized segment consisting of terminal ileum appendix cecum ascending colon

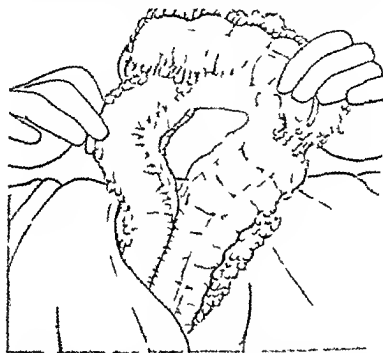


Fig. 356—Ileocolic segment completely mobilized and exteriorized. Ileum sutured to transverse colon to form spur.

hepatic flexure and right half of the transverse colon together with their mesenteric and blood and lymphatic vessels is easily exteriorized. The extruded limbs of ileum and transverse colon approximate easily in the outer angle of the transverse incision without kinking or twisting. The normal relationship of the small and large bowel is now reversed since the new junction is effected with the small intestine entering from the right rather than from the left.

6 *Formation of the Spur*—The spur is formed by suturing

together the extruded loops of bowel and their mesenteries. The cut margins of the mesenteries of the terminal ileum and of the transverse colon are united with interrupted sutures beginning at the depths of the wound and continued outward to the skin surface (Fig 355). Union of the mesenteries helps to hold the extruded limb of intestine in apposition and prevents herniation of the loops of small bowel into the lesser peritoneal space. The antimesenteric margins are joined together with interrupted suture of No. 1 silk threaded in fine needles great care

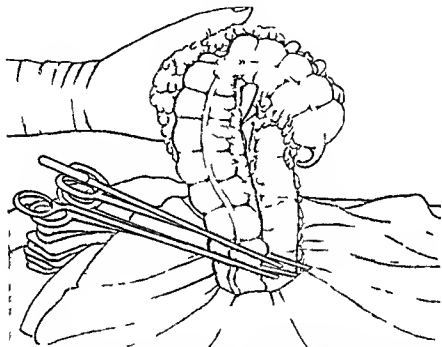


Fig 357—Wound completely closed about extruded loops of bowel and protected by rubber dam Kocher clamp applied

being taken not to include the mucosal layer in the bite of the suture. The suture line should be at least 10 cm. in length (Fig 356).

7 Closure of the Abdominal Wound—The united limbs of the ileum and transverse colon are elevated from the wound until at least 2 inches of viable intestine is raised above the skin surface. The posterior rectus sheath is closed about the extruded intestinal loops lying in the lateral part of the incision with interrupted nonabsorbable suture material so that stay sutures are not necessary. The anterior rectus sheath and linea alba are

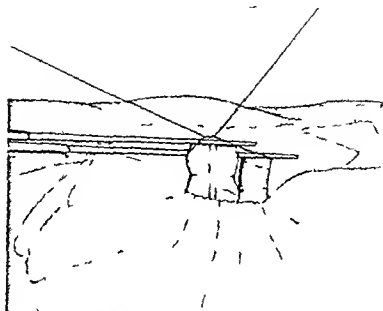


Fig 358—Ileo cecal segment exposed by incision. The protruding loops of bowel held in apposition by silk ligature

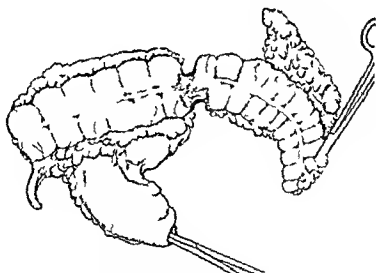


Fig 359—The resected specimen

closed with interrupted figure of 8 No 0 chromic catgut and the skin with interrupted fine silk sutures. The layers are closed

loosely about the bowel but no sutures are used to join the bowel to the abdominal wall

8 *Amputation of the Bowel*—The usual gauze sl in dressing is applied to the wound and over this a sheet of rubber dam is placed for added protection. A 10 inch Ochsner clamp is placed on each loop of extruded bowel allowing for at least 2 inches of viable intestine between the skin surface and the clamps (Fig 357). The intestines are severed with the actual cautery after applying a second row of clamps above the first (Fig 358) and the whole ileocecal segment is removed (Fig 359). Cauterization of the remaining cut ends of the bowel and application of dressings completes the operation. Delaying removal of the involved bowel until the wound is closed and dressed practically obviates the possibility of infection in the peritoneal cavity or the incision itself.

After care

If the Miller-Abbott tube is functioning the clamp need not be removed from the ileum for forty eight hours at which time the extruded loops of bowel are adherent to the sl in and the wound is sealed off. It is extremely important to protect the surrounding sl in from the irritating intestinal contents by liberal amounts of aluminum ointment applied before the ileum is opened. The spur can be crushed as soon as the small intestine is functioning normally so that at least partial intestinal continuity is restored before the patient leaves the hospital. Closure of the stoma should not be attempted for at least six weeks during which time the patient will do better at home than by remaining in the hospital. A second crushing of the spur is usually necessary before closure is attempted.

CONCLUSION

The right colon is eminently suitable for application of the Mikulicz plan of resection for tumors involving this portion of the intestine because of the constancy of the vascular pattern and the facility with which mobilization of the ileocecal segment can be effected. The Mikulicz principle is definitely indicated when obstruction is present or when resection has to be performed on an unprepared patient.

The only real drawback to the operation is irritation of the

skin around the temporary ileostomy. This complication is easily controlled by applying a paste of powdered aluminum in a lanolin base.

SUMMARY

1. The rationale of the application of the Mikulicz principle of resection of the right colon is outlined.
2. The indications for the operation are mentioned.
3. The advantage and disadvantages are pointed out.
4. The steps of the operation are described.

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A COOPER'S LIGAMENT HERNIOTOMY

Clinical Experience in 322 Consecutive Cases*

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and

SAMUEL A. SWENSON, Jr., MD

In a period of a little over three years a total of 322 hernial repairs was performed on the service of the senior author (H.N.H.) using a Cooper's ligament technic. During this same period of time approximately 100 repairs were done by the better known Bassini or original Halsted methods, most of them during the early period of this study. At that time the Cooper's ligament technic was applied only to the more difficult cases with large or direct hernias. Thus any selection of patients with respect to difficulty practically always favored the orthodox methods and was to the disadvantage of the Cooper's ligament technic. More recently practically all of our groin hernias have been repaired using the latter method and since September 1, 1941, the senior author has employed it in eighty-four consecutive personal cases.

This newer operation consists in brief of two essential features: (1) Those structures usually sutured to Poupart's ligament are fastened instead to Cooper's ligament (the ligamentum pubicum superius, B.N.A.). (2) Essentially the same technic can be used for all groin hernias, whether indirect or direct, inguinal or femoral, and whether simple, sliding, incarcerated, or strangulated.

HISTORICAL

The principle of suturing the transversalis fascia and attached structures to Cooper's ligament is not new. Apparently Narth (1898) was the first to use this technic, but especial credit should

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SUMMARY

- 1 The rationale of the application of the Mikulicz principle of resection of the right colon is outlined
- 2 The indications for the operation are mentioned
- 3 The advantage and disadvantages are pointed out
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REFERENCE

- Lafey, Frank H. and Colcock, Bentley. A Modified Mikulicz Resection for Cancer of the Colon. *S. Clin. North America* 22: 3-8 (June) 194

The anatomic studies of McVay done under the direction of Anson in the Department of Anatomy of Northwestern University and later applied to the surgical repair of hernia by McVay are succinctly expressed in the previous paragraph. After hearing a lecture by McVay in April 1940 the senior author began the present study. After applying McVay's principles to



Cooper's ligament Lacunar ligament Inguinal ligament

Fig. 360—View of left half of pelvis with attached ligaments. The relationships between the firmly anchored Cooper's ligament and the loose inguinal ligament are clearly shown.

the surgical repair of 322 groin hernias we have little to find at variance with his opinions.

Cooper's Ligament (*Ligamentum Pubicum Superius*)

The relationships between this structure and the pubis below and Poupert's (inguinal) ligament above are clearly shown in Fig. 360. Cooper's ligament has received relatively little atten-

tion in the literature Seelig and Tuholske (1914) stated It is equally unfortunate that probably the most important structure utilized in the closure of the femoral ring namely Cooper's ligament is not only not pictured in any of the anatomies but also is not adequately described in most of them Cooper's ligament was first described by Sir Astley Cooper (1804) when he cited the os pubis as being covered by a ligamentous expansion which forms a remarkably strong production above the linea ilipectinea extending from the tuberosity of the pubis outward and projecting from the bone over that line

TECHNIC

General Principles

The general principles of our method include the following items

1 Sill sutures were used throughout in all cases In no instance in our 372 hernias was a single sill suture extruded from the wound Except for purse string sutures all stitches were of the interrupted type

2 Spinal anesthesia was employed in most cases It is felt that the greater relaxation given by this type of anesthesia outweighs its possible disadvantages Occasionally the spinal anesthetic had to be supplemented by ethylene ether and in older patients or other poor risk cases local anesthesia was preferred

3 Skin shaving and sterile preparation were done the evening before followed by the application of 3.5 per cent iodine at the time of operation Skin towels fastened to the wound edges were used in all instances

4 Bed rest was advocated in simple unilateral cases for twelve days with discharge from the hospital on the fourteenth day Patients with bilateral hernia were kept in bed fifteen days and those with recurrent hernia nineteen days Return to full manual labor was permitted in five weeks for the simple cases and in six weeks for the bilateral or recurrent hernias

5 The time required for the operation is no greater than for the more conventional procedures The only special equipment needed is a round small curved Mayo needle and a good needle holder A Bland needle holder is desirable but not essential

Steps

The technic can essentially be divided into ten steps. A step by step outline of the procedure follows.

1 *Exposure of the Cord and Opening of the Indirect Sac*—The skin incision is made from 1 cm medial to the antero superior iliac spine to over the pubic spine exposing the external oblique aponeurosis. The external ring is exposed and the

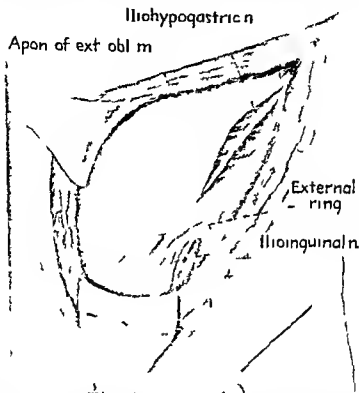


Fig 361—Skin incision and beginning of incision of the external oblique aponeurosis. The latter is usually made in the direction of the fibers of the aponeurosis so that the opening will be even with the upper border of the external ring. The underlying iliohypogastric nerve is carefully av

external oblique aponeurosis split in the direction of its fibers, even with the upper border of the ring. This splitting is begun 3 cm from the ring with the scalpel as shown in the diagram. The split is then extended laterally and upward and then more carefully downward in the direction of the fibers to the external ring after meticulously peeling away the ilioinguinal nerve which is often adherent to the underlying external oblique aponeurosis at this level. When

cident usually occurs near the external ring and may be prevented by approaching the latter from the lateral side. The cord and surrounding structures are then separated from the lower leaf of the external oblique aponeurosis and Poupart's ligament and then from the region of the pubic spine and conjoined tendon so that finally the cord is freed entirely except

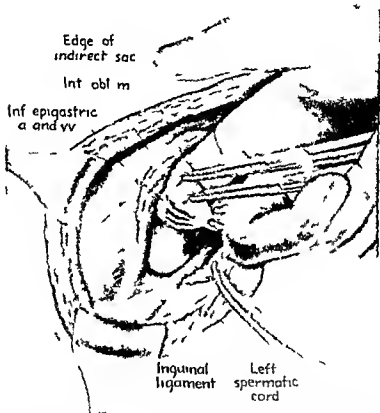


Fig 36 ~The indirect sac is always opened and any femoral or direct sacs transposed by the method of Hogue to become part of the indirect sac. In the above figure the tip of the examining finger is in the small direct sac.

at both ends. The indirect sac which is always present even in normal individuals is located upwards and medialward from the internal ring and is then opened not only in indirect and combined types of hernias but also in simple direct or femoral hernias. If the indirect sac is long it is bisected after careful separation from the cord near the internal ring. The distal seg

ment is usually left undisturbed and rarely causes trouble but if easily separated is removed. The proximal segment is grasped with Halsted clamps at points around the circumference of the internal ring.

2 *Exploration*—The large number of small femoral or direct hernias that recur after an indirect inguinal herniotomy is in many instances testimony against the inaccuracy of the diagnosis rather than the incompetency of the procedure. It is in

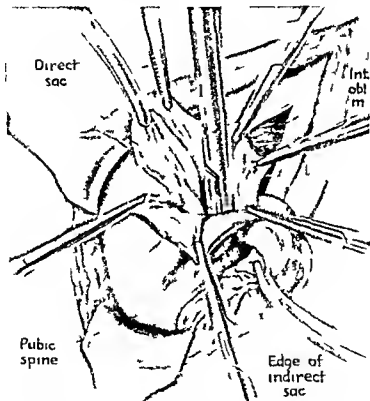


Fig. 363—The direct sac has now been transposed and the gauze tipped Kuttner dissector is holding back the intestines.

deed surprising how few surgeons will place an index finger into the abdomen through an indirect sac for purposes of exploration of the femoral ring and Hesselbach's triangle even though the sac lies open before them. Exploration with the finger tip should be an essential feature of all hernial repairs.

3 *Hoguet Maneuver*—If a direct sac or weakness is present as shown in Fig. 367, it should be transposed laterally to the inferior epigastric vessels by the technic of Hoguet (1920).

which has since been popularized by Fallis (1938). Thus the direct and indirect sacs are converted into one. This step may be described in Hoguet's own words as follows: By traction outward on the indirect sac all of the peritoneum of the direct sac may be pulled external to the vessels and the two sacs converted into one. An indirect sac can always be found in these cases although it may be very small. The same procedure

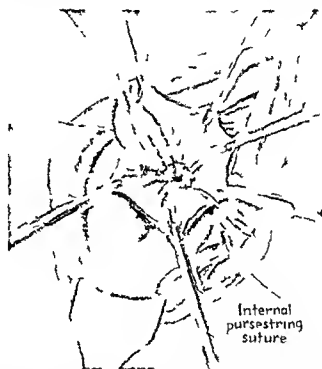


Fig. 364—The sac is now closed by an internal purse string suture which obliterates all of its folds. The redundant sacs usually replaced in the internal ring but if large may be excised.

may be used to convert a femoral sac into an indirect sac as practiced by McClure and Fallis (1939). In some instances all three sacs can be converted into a single indirect sac which in turn can always be dealt with as described in Step 4.

4 *Internal Purse string Closure of Indirect Sac*—The indirect sac, whether it be simple or enlarged by the conversion of direct and femoral sacs, is then closed with an internal purse string suture of No. 5 heavy silk. Many bites are taken so as to

include all crevices and the suture is placed with a round non cutting needle as high as possible as shown in Fig. 364

5 *Plastic on the Internal Ring*—When the purse string suture is cut and the peritoneum snaps back the defect in the transversalis fascia at the internal ring is seen to be quite large in many instances and will admit even three or four fingers. The fascia is grasped with Allis clamps at numerous points around

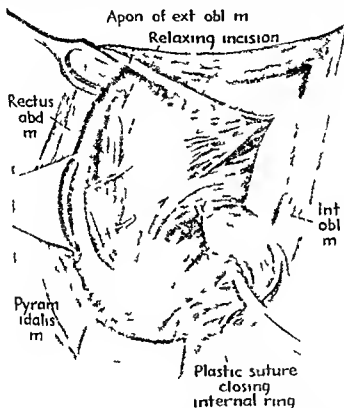


Fig. 365—The internal ring has now been closed by a plastic stitch in the transversalis fascia while the internal oblique has been relaxed close to where it joins the external oblique aponeurosis to form the linea alba. In making this relaxing incision an attempt is made to spare the nerves.

the internal ring above and medially as far as the inferior epigastric vessels but not inferior to the cord and a second partial purse string suture of heavy silk placed in the transversalis fascia. This makes a snug fit around the cord. (The purse string itself does not surround the cord.)

6 *Relaxation of the Internal Oblique*—The inner layer of the anterior rectus fascia is routinely split for a distance of

about 3 inches from the point 1.5 cm above the pubic spine upward and lateralward. This is done almost exactly as described by Rienhoff (1940) and as shown in Fig. 365. The external oblique is lifted up by the assistant and the internal oblique cut just lateral to the junction of the two to form the linea alba. The rectus and pyramidalis muscles are exposed. The iliohypogastric and adjoining nerves and vessels which enter the rectus muscle through the internal oblique aponeurosis at this point can be avoided easily. This relaxation allows the internal oblique and attached transversalis fascia to be pulled down for the subsequent repair without tension.

7. *Cooper's Ligament Sutures*—The red muscle of the internal oblique is entirely disregarded and even may be excised for convenience where it overlies the conjoint tendon. Usually it is elevated with a small retractor and the conjoint tendon located with a gauze (Kuttner) dissector. If the transversalis fascia alone appears strong enough it alone is used for the upper leaf of the repair. If it is not adequate one must go higher and include the internal oblique aponeurosis. In no instance however should red muscle be used. The transversalis fascia and often the conjoint tendon therefore form the upper leaf of the repair while Cooper's ligament is the lower leaf. The left index finger is placed on the anterior ramus of the pubis near the spine and moved laterally along the crest until the femoral vessels are reached. This is usually about 5 cm lateral to the spine of the pubis. Since the finger is held in close contact with the bone keeping the vessels lateral and the first stitch is placed medial to the finger there is little danger of damaging the vessels. The first stitch thus is usually 4 cm lateral to the pubic spine. Therefore since the upper leaf is to be grabbed with the suture first the needle goes through the transversalis fascia a corresponding distance of about 4 cm from the pubic spine and then through the thick Cooper's ligament on the upper border of the pubic ramus locating the ligament by feeling the bone with the needle. This stitch is then tied as shown in Fig. 366 and the intervening gap between this point and the pubic spine is closed with three or four similar sutures as shown in Fig. 367. The most medial sutures usually go through Gimbernat's (lacunar) ligament as well as Cooper's. It is important that the most lateral suture be

placed first for otherwise it is more difficult to protect the vein. The sutures into Cooper's ligament are of double No. 5 heavy braided silk and are applied with a small round curved Mayo needle held with a Bland needle holder. The double strands are made into a triple knot and then the individual strands are separated and tied in pairs. The relatively large amount of silk

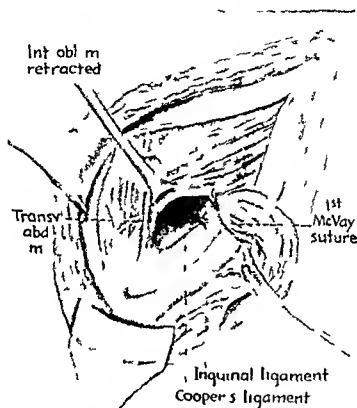


Fig. 366.—The first Cooper's ligament suture has now been placed. This is inserted through the transversalis fascia and adjoining conjoint tendon above and Cooper's ligament below. The most lateral suture is placed first. This is separated from the femoral vessels which lie laterally by the tip of the left index finger of the operator which is held tightly in contact with the pubic bone underlying Cooper's ligament.

used has never caused trouble. In certain cases because of the prominence of Rosenmüller's gland (a lymph gland lying over Cooper's ligament about 2 cm medial to the femoral vessels) or because of doubt as to the position of the vein the sutures are carried out only halfway or more from the pubic spine to the femoral vessels. This is termed a partial operation or a partial McVay and will be discussed more in detail later. In

our 185 most recent cases this had to be done only once (0.6 per cent)

8 *Closure of the External Oblique Aponeurosis*—In the early cases of our series the external oblique aponeurosis was closed beneath the cord after the manner of the original *Hilsted* procedure in the majority of cases (83 out of 157 or 61 per cent). More recently, however, it has most often been closed

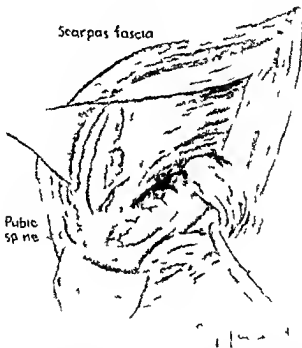


Fig. 367—All of the Cooper's Ligament sutures (illegible) have now been placed. The most medial two or three of these sutures also pass through the lacunar (iliac) ligament. The cord is then dropped into the dead space and the external oblique, Scarpa's fascia and skin are closed with interrupted silk sutures in layers over the cord.

over the cord, the latter being dropped into the dead space left by the Cooper's ligament closure. Thus, more recently, the usual closure of the external oblique has been in a typical Bassini manner (177 out of 185 or 96 per cent). We call these two variations of the procedure the *Hilsted* and *McVay* and the *Bassini-McVay*. There have been no recurrences by the latter method and one by the former. In either instance, the external

oblique is closed with interrupted No 1 silk sutures using very little if any imbrication

9 *Closure of Scarpa's Fascia*—Closure of Scarpa's fascia with small bites of the suture seems more anatomic and leaves less sill than does suture of the fat with large bites taken at random. The sutures are preferably placed so that the knot will be down.

10 *Skin Closure*—Interrupted silk end on mattress sutures are advisable for this step. The proper closure of the lower third of the wound inside the hair line is of especial importance.

ANALYSIS OF CASES

Using the Cooper's ligament technic described above as especially advocated by Lotheissen and others and more recently by McVay we have repaired 322 groin hernias in 259 patients during the thirty eight month period April 23 1940 to June 24 1943. Since August 31 1941 the senior author has used this technic for all cases.

Sex—The predominance of males in our series as shown in Table 1 reflects the usual sex difference which is much exaggerated by the industrial nature of our clientele.

TABLE 1

SEX OF PATIENTS	No of Patients	Percentage
Male	254	91
Female	5	9
Total	259	100

Side—The right side was operated upon most often as shown in Table 2 while in sixty four instances a bilateral McVay procedure was performed. This table refers to this type of operation only in several instances especially in the early portion

TABLE 2

SIDE OF OCCURRENCE	No of Patients	Percentage
Right alone	107	41
Left alone	88	34
Bilateral	64	25
Total	259	100

of the series other procedures were done on the other side which are not listed. In every such instance the Cooper's ligament technic was performed on the side with the largest hernia. For technical reasons a left sided McVay operation is more difficult to perform than a similar operation on the right side for a right handed surgeon.

Size of Hernia—In a series of 300 hernias where the size was recorded 120 were listed as large (sac 10 cm. or over in its longest diameter) 113 as medium (sac 5 to 10 cm.) and 67 as small (sac less than 5 cm.) (Table 3).

TABLE 3

SIZE OF HERNIAL SAC	No of Hernias	Percentage
Large	120	40
Medium	113	38
Small	67	22
Total	<u>300</u>	<u>100</u>

Classification—As seen in Table 4 the proportion of the various types of hernia represented is approximately that found in an average series. The one exception to this statement is the

TABLE 4

TYPES OF HERNIA REPRESENTED

Classification	No of Hernias	Percentage
Simple indirect	141	43
Simple direct	80	25
Indirect and direct (saddle bag)	56	17
Femoral and indirect	8	2
Femoral and saddle bag	3	1
Sliding	2	1
Incarcerated	4	1
Recurrent indirect	12	1
Recurrent direct	18	6
Recurrent saddle bag	1	0.3
Total	<u>325</u>	<u>100.3</u>

Including several duplications

large number of patients with direct inguinal weakness. This is partly because early in the series when the Cooper's ligament procedure was still viewed somewhat as an experimental trial

it was used especially for direct hernias. Later however it was used in all cases and during the past twenty two months the senior author (H N H) has used no other type of repair. Another reason for the large number of direct hernias is that with routine inspection of Hesselbach's triangle with the gloved index finger from inside we detect a large number of direct weaknesses that would otherwise go unnoticed. We have used this technic for a large variety of hernias. It was applied even in one case with traumatic rupture of the bowel in the hernial sac no wound infection resulting.

TABLE 5

SURGEON	No of Hernias	Percentage
Harkins	164	51
Grego	45	14
Szilagy	38	12
Groesbeck	21	7
Swenson	16	5
Zabinski	16	5
Williams	9	3
Brush	6	2
Schug	1	0.3
Oleck	2	0.6
Boals	1	0.3
Hooker	1	0.3
Neel	1	0.3
Romence	1	0.3
Total	37	100

Type of Operation—Table 5 demonstrates that while about half the operations (51 per cent) were done by the senior author the rest (49 per cent) were done by thirteen of his assistants who came on the service in rotation during a period of slightly over three years. This demonstrated that the operation can be performed by a number of men. Table 6 shows that while in the early cases the Halsted I McVay was the most popular procedure recently it has been almost entirely abandoned only eight (4 per cent) of the last 185 cases being done this way. This table also illustrates that in the recent series the operation called the partial McVay has been found necessary in only one case.

Follow up—While all of the cases were checked at varying intervals after operation in only thirty five instances (31.2 per

TABLE I
TYPE OF OPERATION

Operation	Early Cases		Recent Cases		Total Cases	
	No. of Hernias	Percentage	No. of Hernias	Percentage	No. of Hernias	Percentage
Basson McVay	44	32	16	95	20	68
Husted McVay	63	46	8	4	71	22
Partial Basson McVay	10	7	1	1	11	4
Partial Husted McVay	20	15	0	0	20	6
Total	137	100	185	100	322	100

cent of the first 112 cases in which operation was done more than two years ago) is there a follow up of two years or more as shown in Table 7. Only one recurrence has been found, it being after a Halsted I McVay operation done by one of the

TABLE 7

FOLLOW UP

	No of Patients	Percentage
Less than six months	35	31.2
Six months to one year	26	23.2
One year to eighteen months	8	7.2
Eighteen months to two years	8	7.2
Two years or over	35	31.2
Total	112	100

younger assistants in December 1940 which was discovered in April 1942. This was a bilateral hernia and the recurrence was present on only one side the sac measuring 2 cm in diameter and occurring over the internal ring which probably had not been made snug enough. Since in Fallis series of 800 hernias the recurrence rate at the end of one year was already 4.2 per cent (despite the ultimate maximum of only 8.5 per cent) this indicates that our series is at least no worse than other series with a good ultimate result. However we wish to draw no premature conclusions in this regard and a study of the recurrence rate is not the prime purpose of our report.

SUMMARY AND CONCLUSIONS

1. Based on the theory that the transversalis and internal oblique fibers do not normally attach themselves to Poupart's but rather to Cooper's ligament a hernial repair has been utilized which attempts to restore the normal attachments to Cooper's ligament. In this operation a Cooper's ligament herniotomy, no fascial layer is sutured to Poupart's ligament.

2. This technic has been used in the repair of 322 groin hernias of several types in 259 patients during a thirty eight month period. While the follow up studies are not yet complete the results indicate that the procedure justifies its theoretical advantages. To date only one recurrence has been found.

3 An identical procedure is used for all of the main types of groin hernias indirect inguinal direct inguinal and femoral. The fact that only one technic need be learned is another advantage of this method.

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TREATMENT OF SIMPLE FRACTURES OF THE SHAFT OF THE TIBIA IN ADULTS A COMPARATIVE STUDY

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In the past few years it has become increasingly apparent to the writer and his associates that fewer cases of delayed union and nonunion of fractures of the tibia are being encountered. The improvement in results obtained was thought to be due to the fact that more primary open reductions of these fractures have been done in the last three or four years than heretofore but a critical analysis of the cases was deemed necessary before definite conclusions could be reached. Our treatment of these fractures for many years had erred perhaps on the side of conservatism and primary open reduction was resorted to in only those fractures that were irreducible by other methods. Skeletal traction by means of Kirschner wire or a Steinmann pin through the os calcis was utilized in the majority of tibial fractures that could not be reduced by manipulation and plaster immobilization.

This latter practice was largely discontinued in 1939 and since that time almost all simple fractures either comminuted transverse or oblique that were irreducible or uncontrollable by manipulation and plaster immobilization have been subjected to open reduction. In a few cases the two pin method of reduction and immobilization was used but this was not thought to be as satisfactory in severely comminuted fractures and in our opinion had no distinct advantage over primary open reduction and titanium screw fixation in oblique fractures.

This series includes fractures of the shaft of the tibia in adults observed in the years 1935 to 1941 inclusive. Compound fractures and fractures involving the articular surfaces have not

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been included. Only those cases that were followed at the clinic are included as a number of patients went elsewhere following reduction of the fracture and no follow up on these cases was made for this series. The criteria of bony union used in this series were absence of motion at the fracture site on careful clinical examination and x-ray evidence of adequate callus formation. This corresponded with the time that support was removed from the extremity and unprotected weight bearing permitted.

For purpose of comparison the series has been divided into three groups according to the method of treatment used as follows:

- 1 Skeletal traction
- 2 Manipulative reduction and plaster immobilization
- 3 Primary open reduction

1 Skeletal Traction

Thirty seven cases of fracture of the tibia in this series were treated by means of skeletal traction using Kirschner wire or a Steinmann pin through the os calcis (Table 1). Of these fractures thirty one were comminuted and six were oblique. During the period of time that skeletal traction was being used extensively most of the oblique fractures were treated by manipulation and plaster immobilization.

TABLE 1

FRACTURES OF TIBIA TREATED BY SKELETAL TRACTION

Total number of cases	37
Nonunion	8 or 21.6%
Comminuted middle third	4
Comminuted lower third	4
Open reduction because of poor position	2
Comminuted	31
Transverse	0
Oblique	6
Average time for union	4.47 months
Average time in hospital	41.5 days

A total of eight cases or 21.6 per cent of fractures treated by skeletal traction developed nonunion and open reduction with bone grafting was necessary in these cases. Four of these cases

were comminuted fractures of the middle third of the tibia and four were comminuted fractures of the lower third

Two cases were operated upon a few weeks after traction had been instituted because of inability to secure satisfactory reduction. In the remaining twenty seven cases the average time for bony union was 4.47 months. Ten of these cases required five months or longer before union took place. The average time for hospitalization of this entire group was 41.5 days.

2. Closed Reduction and Plaster Immobilization with or Without Preliminary Manipulation

There were sixty five cases in this group with the patients ranging in age from eighteen to seventy five years and an average age of forty years (Table 2). Thirty five of the fractures in this group were comminuted, twenty three oblique and seven transverse. In only four or 6.15 per cent of these fractures did nonunion develop. Of these two were comminuted at the junction of the upper and middle third, one was comminuted in the middle third and one was transverse in the middle third. Three cases were subjected to open reduction within a few weeks following the injury because of nonmaintenance of reduction.

TABLE 2

FRactures of the Tibia Treated by Closed Reduction and Plaster Immobilization with or without Preliminary Manipulation

Total number of cases	65
Nonunion	4 or 6.15%
Comminuted junction upper and middle third	1
Comminuted middle third	1
Transverse middle third	1
Open reduction because of poor position	3
Comminuted	35
Transverse	7
Oblique	23
Average time for union	3.26 months
Average time in hospital	16.8 days
Average age	40 years
Time for union in patients under 40 (32 cases)	3.49 months
Time for union in patients over 40 (33 cases)	3.11 months

The average time for bony union in this group was 3.26 months and the average time spent in the hospital was 16.8 days.

An analysis of the cases according to age of patients shows no appreciable difference in the length of time taken for union. There were thirty two patients under forty years of age with an average time for union of 3.49 months. In thirty three patients over forty years of age healing was complete in an average time of 3.11 months.

3 Primary Open Reduction

Twenty three cases are included in this group open reduction being carried out in from four hours to three days following the injury (Table 3). The method of internal fixation used varied according to the type of fracture and the time during the period of this study that the patient was treated. Parham band and wire fixation for example were used as means of internal fixation prior to the introduction of vitallium plates and screws and subsequently their use was discontinued. Internal fixation methods used were as follows: Parham band three cases, wire three cases, vitallium screws four cases, vitallium plates and screws twelve cases. In one case no internal fixation was used.

TABLE 3

FRACTURES OF TIBIA TREATED BY PRIMARY OPEN REDUCTION

Total number of cases	23
Nonunion	1 or 4.3%
Parham band fixation—comminuted fracture middle third	
Comminuted	9
Transverse	1
Oblique	13
Average time for union	3.49 months
Average time in hospital	13.7 days
Infected wounds	0

There was one case of nonunion or 4.3 per cent. This was in a comminuted fracture of the middle third of the tibia for which a Parham band was used for internal fixation. In this group nine of the fractures were comminuted, one was transverse and thirteen were oblique. The average time for union in this group was 3.49 months and the average time in the hospital was 13.7 days. None of the wounds became infected.

SUMMARY AND CONCLUSIONS

It would seem apparent from a study of the series of cases that skeletal traction by means of a pin or wire through the os calcis for treatment of simple fractures of the tibia should be reserved for those fractures that cannot be reduced and maintained in position in plaster and in which open reduction is contraindicated. Although skeletal traction is used much less frequently by surgeons today it is still an optional method and the writer believes that serious consideration should be given before adopting it in a given case. In addition to the high percentage of cases of delayed and nonunion encountered it should be borne in mind that it is necessary to hospitalize these patients for a much longer period of time than with other methods and there is also the increased danger of decubitus ulcers, peroneal nerve paralysis and pulmonary embolism.

A review of this series indicates that closed reduction with plaster immobilization and manipulation when indicated yields a high percentage of excellent results. It is interesting to note that in twenty three cases of oblique fractures of the tibia treated by this method nonunion did not result. In two cases however position was not maintained and open reduction became necessary. The average time for union in this group was 3.26 months which was shorter than by other methods, and the average time of hospitalization was 16.8 days which compared very favorably with the time required in fractures treated by primary open reduction. However reduction in this group of cases was usually not anatomic and often a certain amount of length was sacrificed and in a few instances a slight amount of angulation and rotation resulted. The functional end result however was excellent in almost all cases.

Primary open reduction resulted in the smallest percentage of nonunion (4.3 per cent) and the shortest average time in the hospital (13.7 days). Weight bearing with the aid of a plaster walking boot was permitted in from three to four weeks after operation thus resulting in quicker restoration of function. Primary open reduction was performed in cases of oblique fractures that were irreducible or uncontrollable by plaster immobilization and in comminuted fractures with distortion or overriding of the fragments with appreciable shortening.

Vitallium screws were found to be quite satisfactory for

oblique fractures and vitallium plates and screws for comminuted fractures. The plates were placed on the lateral surface of the tibia whenever possible in preference to the anterior subcutaneous surface. A few of the plates placed in the latter position were subsequently removed because of overlying skin irritation.

A comparison of the three groups in this relatively small series of cases would appear to indicate that primary open reduction in selected cases of fractures of the tibia using vitallium plates and screws is the treatment of choice with respect to the development of union and time of restoration of function.

PULMONARY EMBOLISM METHODS OF PREVENTION*

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THERE is general agreement concerning the incidence of fatal and nonfatal embolism following operation. The largest published statistics are those of the group at the Mayo Clinic.¹ In 172,888 operations of all types there were 897 pulmonary emboli of which 343 were fatal. This indicates an incidence of 0.5% per cent (approximately one in 200) and 0.20 per cent (one in 500) for all embolism and fatal embolism respectively. De Talats and Jesser² stated that in their survey of the literature it was found that from 0.1 per cent to 0.2 per cent of all patients operated upon died from this cause. It accounted for 2 per cent of all deaths and 6 per cent of all postoperative deaths and was found in 10 per cent of all autopsies. Lam and Hooler³ studied the Henry Ford Hospital material and found 65 fatal emboli in 104,884 operations of all kinds over a period of nineteen years. It is with the prevention of these deaths that this paper is concerned.

Preventive measures fall into two groups: (1) purely prophylactic measures which can be regularly applied to all or nearly all postoperative cases and (2) special or more radical procedures which are used in certain cases where there is evidence of thrombosis with increased risk of fatal embolism. In the first category are such measures as leg exercises, regular and frequent turning in bed and the head down or Trendelenburg position. Murray⁴ of Toronto has used heparin in unselected cases in a prophylactic manner and there are several reports on the similar use of dicumarol.^{5, 6, 7, 8}

When a patient has had a nonfatal embolus or shows evidence of thrombosis in a leg, the procedures in the second category should be used to minimize the danger of a subsequent fatal episode. These measures are heparinization, dicumarol therapy.

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and femoral or iliac vein ligation with or without previous venography

PURELY PROPHYLACTIC MEASURES

There is no doubt that the slowing of the venous return from the lower extremities is an important factor in thrombosis. Contraction of the leg muscles and respiratory movements which are concerned in the return of blood to the heart are inhibited in the postoperative state. Hence a number of *exercises* have been devised to correct this factor of inactivity. The papers describing these procedures contain favorable reports on a fair number of cases but the results are not statistically significant. Added together, however they attest to the value of almost any type of exercise.

In 1913 Pool⁹ described a dozen exercises which were to be repeated ten to thirty times on three occasions daily and suggested that their use would speed up convalescence in general in addition to inhibiting thrombosis. Potts¹⁰ writes the following order to take effect the day following operation on all patients above twelve years of age. Have the patient take 15 deep breaths morning and evening and with each deep breath actively flex the legs. He reported that 518 patients carried out these exercises and there was no instance of pulmonary embolism or thrombophlebitis. During the same period a control group of ninety five patients who did not exercise an account of fracture fixation apparatus were observed five of these developed thrombophlebitis of which three were followed by nonfatal pulmonary embolism. Cogswell¹¹ attempted to carry out a similar regimen but the results were not so good. In 320 patients there were two cases of phlebitis and two of embolism. He thought that there might have been poor cooperation of the patients and nurses. He then began to use a bicycle pedal arrangement having the patients exercise for five to fifteen minutes daily. Over a one year period 403 patients used the device and none developed thrombo-embolic manifestations.

There are several reports on the use of the *Trendelenburg position*. The rationale is that the return of venous blood from the lower extremities is facilitated by the effect of gravity. Gray¹ at the Mayo Clinic used the position for 276 patients and found a decreased incidence of all pulmonary complications as compared with a larger control group. The complications

were not divided with regard to infectious or embolic origin. The method has not been stressed in later papers from that clinic.⁶⁻¹² Dr. Trkats and Jesser observed 350 patients who had been placed in this position; there was no postoperative thrombosis while a control group of 1000 patients showed five cases.

No controlled study of the prophylactic effect of exercise and position has been carried out at the Henry Ford Hospital. Dr. Roy D. McClure has always urged his own patients to be active in bed and in many instances has ordered physiotherapy to the extremities. The following nurses' orders are routine for general surgical patients who have had operations:

1. Rub and move the patient's extremities every fifteen minutes unless contraindicated until he is fully awake.

Turn the patient unless contraindicated every half hour until he is fully awake and every two hours thereafter.

Instruct the patient as soon as possible to breathe deeply ten times every half hour and move the legs every half hour while awake.

It is believed that the above program if carried out would prevent the beginning of thrombosis in most patients. Inevitably it will fail occasionally because it depends on the human element in such heavily sedated or uncooperative patients and an understaffed wartime nursing personnel.

SPECIAL MEASURES USED IN ESTABLISHED THROMBOSIS

Anticoagulants

The use of the anticoagulants *heparin* and *dicumarol* in the treatment of thrombosis implies an acceptance of the assumption that although clots which have already formed cannot be dissolved it is advantageous to inhibit further coagulation. The present status of our knowledge of the mode of action of the two substances will be reviewed briefly. Both apparently act on the prothrombin but in different ways. Dicumarol prevents the manufacture of prothrombin in the liver but has no effect on that which is already in the blood stream. Heparin does not interfere with the formation of prothrombin but in some way it prevents the change from prothrombin to thrombin and when administered in sufficient doses at appropriate intervals it renders the blood immediately incorrigible to any desired degree.

To illustrate these reactions and other factors affecting prothrombin I had a cartoonist prepare the semicomical sketch shown in Figure 368. The diagram illustrates the fact that dicumarol does not immediately affect the clotting mechanism because forty eight to seventy two hours must pass before the prothrombin store is used up. On the other hand an intravenous dose of heparin immediately inactivates the prothrombin on hand but the effect lasts only two or three hours. This difference in mode of action makes possible a convenient combina-

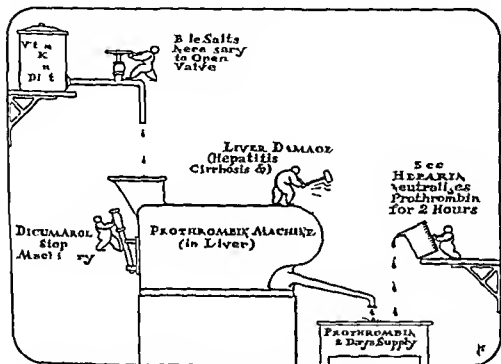


Fig 368—A cartoonist's summary of the currently accepted conception of the action of dicumarol, heparin and other factors influencing plasma prothrombin.

tion treatment when it is desired to prevent thrombosis for a week or more. One would start heparin and dicumarol simultaneously, stopping the heparin in two or three days after the dicumarol effect had appeared.

Technic of Heparin Administration—Heparin is given intravenously, preferably by continuous drip. The material is dispensed in 10 cc vials containing 100 mg of the crystalline salt corresponding to 10,000 Toronto units. It is convenient to add one of these vials to 500 cc of physiologic saline solution,

allowing the mixture to drip in at the rate of 15 to 20 drops per minute. The rate of flow must be adjusted for each patient so that an arbitrary optimum clotting time of fifteen minutes is maintained. At the beginning of treatment it is necessary to give the solution rapidly i.e. at the rate of 50 to 60 drops per minute or 5 cc of the undiluted heparin may be injected at once. The clotting time should be tested every hour until a stable level is reached and three times daily thereafter. The capillary tube method is the simplest for it does not require a venipuncture although it is admittedly less accurate than the multiple test tube method using venous blood.

The selection of the vein for the continuous drip should be done with some care. Originally I used a cannula in the long saphenous vein at the ankle. This procedure resulted in tran-

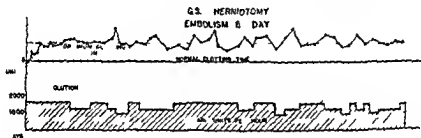


Fig. 369—Ideal heparin chart with clotting time maintained at optimum level of fifteen minutes (capillary tube method) (Courtesy Annals of Surgery)

itory phlebitis in several cases. Now I use a vein on the dorsum of the hand or wrist inserting an ordinary intravenous needle which is fastened securely with tape and bandage so that no amount of moving is apt to dislodge it. No splint is used or at the most a small cock up splint may be placed at the wrist. The patient can use the hand for holding reading material or eating, and the degree of comfort presented is in sharp contrast to that of the patient with a needle in the antecubital area and the elbow splinted in extension. The left wrist is used if the patient is right handed and vice versa. Toward the end of a course of treatment it is possible for the patient to be up in a chair or even to walk about the room with the intravenous drip running.

No hard and fast rule can be laid down with regard to the number of days heparin should be given. The usual course of

treatment lasts about a week or ten days Figure 369 shows an example of good response to heparinization with satisfactory elevation of the clotting time for a period of eight days One should be on the lookout for the following hemorrhagic complications hemorrhage from the operative site hemothorax subcutaneous hematoma epistaxis and hematuria^{14 1} Usually the appearance of any of these complications is the signal to discontinue heparin treatment The clotting time will return to

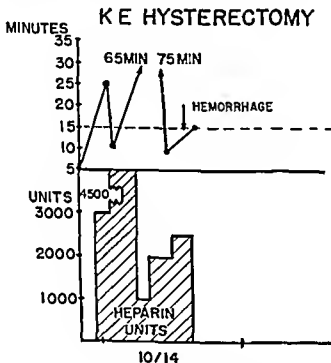


Fig 370—Chart of patient with overdose of heparin which was followed by hemorrhage

normal in two or three hours but occasionally transfusion may be indicated Figure 370 shows the chart of a patient who received too much heparin with the result that the clotting time was maintained at a high level for several hours Profuse bleeding from the wound occurred and transfusion was necessary

Dicumarol Therapy—The new anticoagulant dicumarol is very convenient to give because it may be administered orally in a daily dose It is supplied in 50-mg and 100 mg capsules It has been our policy to give 100 mg per 50 pounds of body weight as an initial dose In no case should this exceed 400 mg

No attempt is made to compute the dose closer than the nearest multiple of 50. The order for subsequent doses reads as follows: Take blood for plasma prothrombin at 8:00 A.M. daily.

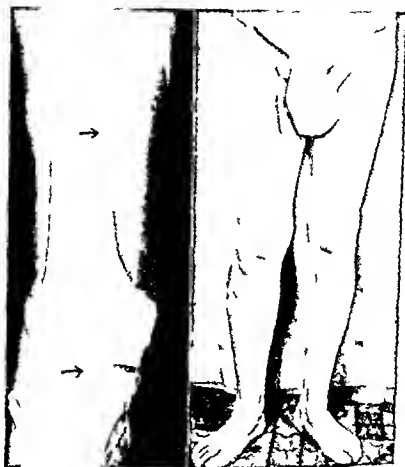


Fig. 371

Fig. 372

Fig. 371—Venogram of right leg of patient M. B. There is a filling defect in the popliteal vein from the point of entrance of the right saphenous (lower arrow) to the entrance of a communicating vein (upper arrow).

Fig. 372—Postoperative photograph of patient M. B. showing the results of ligation of superficial femoral vein. Note the good appearance of the leg six weeks after the operation.

At 4:00 P.M. daily give 100 mg dicumarol unless the prothrombin value of the morning is 10 per cent of normal or below in which case omit the day's dose. Needless to say the drug should not be given until the liver function has been

investigated by checking the prothrombin level. The following case report shows how dicumarol was used in conjunction with femoral vein ligation in a case of thrombosis with pulmonary infarcts.

CASE REPORT—M. B., a retired physician aged sixty-six years, suffered trauma about the trunk and legs when he was beaten by an unknown assailant on March 3, 1943. This injury caused him to remain in bed for several weeks and on March 28 he had sudden pain in the right chest and began to raise bloody sputum. He was admitted to the Henry Ford Hospital a week later. The physical signs of infarct of the right lower pulmonary lobe were present. The calf of the right leg was tender when the foot was dorsiflexed (positive Homan's sign) and a venogram showed a filling defect in the popliteal vein (Fig. 371). This was thought to be the source of the embolus and ligation of the femoral vein was advised. This was done on April 6 according to the method described below. No thrombosis was encountered in the region of the junction of the superficial and deep femoral veins; hence the operation consisted only of section and ligation of the superficial vein. His recovery was uneventful until on May 6 when he was preparing to go home he had a mild attack of pain in the left chest. It was feared that this was due to another small embolus. It was decided to inhibit further thrombosis with dicumarol therapy. The details of treatment and the response of the prothrombin level are shown in the accompanying tabulation.

DICUMAROL DOSAGE SCHEDULE AND THE RESPONSE OF THE PROTHROMBIN IN PATIENT M. B.

Date	Dose of Dicumarol Mg	Prothrombin Per Cent
5/7/43	—	95
5/7	200	—
5/8	100	90
5/9	100	85
5/10	100	40
5/11	100	35
5/12	—	5
5/13	—	10
5/14	—	25
5/15	100	75
5/16	—	60
5/17	100	75
5/18	—	0
5/20	—	90
5/21	—	100

The subsequent course of the patient was favorable. There was no recurrence of the chest pain and he was allowed up on May 15. There was negligible swelling of the right leg (Fig. 372). He was discharged from the hospital on May 22. On June 11 he was observed in the out-patient department; he had gained 20 pounds; there were no chest symptoms and there was no change in the leg.

Results from Use of Anticoagulants—The question of whether lives have been saved by the use of the anticoagulants will now be considered. In the Henry Ford Hospital series, Lam and Hooler³ found that since 1924 there were 187 cases of nonfatal infarction and sixty-five cases of fatal embolism, a total of 252 cases. In seventeen of the fatal cases the patients had had previous nonfatal episodes. Therefore there were 204 nonfatal episodes. Sixty of these were treated with heparin or dicumarol (fifty-three with heparin, seven with dicumarol). Two of the treated group had a second and fatal embolism, giving a mortality rate of 3.3 per cent. Of the 144 untreated cases, seventeen ended in fatal embolism, a mortality rate of 11.8 per cent. Murray⁴ had no deaths in forty-six cases of infarction treated with heparin. At the Mayo Clinic¹³ sixty-three patients with nonfatal pulmonary embolism were heparinized, with two deaths following. This gave a mortality rate of 3.2 per cent, which was much better than the rate of 18.5 per cent in a large untreated group. At the same clinic, sixty-seven patients were treated with dicumarol and there was not a single fatality, whereas thirteen deaths would have been expected without specific treatment.⁵

Femoral Vein Ligation

This procedure has been advocated by Homans¹⁶, Welch and Faxon¹⁷ and Fine and Sears.¹⁸ It has not been carried out in enough cases for statistically significant figures to be collected to prove its exact value in preventing embolism, but the number of cases is mounting and it has been demonstrated that ligation of the superficial femoral vein can be carried out without the development of undue edema. The indications for the operation are simple. I feel that the femoral vein should be ligated whenever there is good evidence of thrombosis of the deep veins of the leg.

The most convincing evidence of thrombosis is obtained by venography. Bauer¹⁹ did 100 venograms and came to the conclusion that the thrombo embolic process almost invariably starts in the deep veins of the lower leg. The method, indications and interpretation of venograms has been presented in detail by Fine, Frank and Starr.⁹

The most successful *venographic technique* in my hands has been according to the following procedure. Under local anesthesia a small longitudinal incision is made just posterior to the lateral malleolus. A constant vein is found here. A small cannula is tied in place, after which a drop or two of heparin is injected into the cannula and the stylet replaced until the syringe with the contrast medium is attached. The use of heparin at this stage allows one to do the operative part of the procedure in the patient's room or elsewhere, after which the patient may be taken to the x-ray department leisurely, since there is no danger of thrombosis. Presumably any contrast medium which is used for intravenous urography can be used for venography, but I have used Diodrast (Winthrop) most often. A 17-inch film is placed under the leg in such a position that when the exposure is made a large part of the thigh and some of the leg below the knee will be shown. The foot is elevated 6 inches and held in slight internal rotation. When the x-ray technician is ready the solution (20 cc. of 35 per cent Diodrast) is injected over a period of 60 seconds, at the end of which time the exposure is made. There is seldom time for a second picture.

If venography or clinical signs indicate thrombosis of the deep veins, the femoral vein is explored in Scarpa's triangle. The pulsation of the femoral artery is located. One per cent novocain is injected in the line of the proposed incision, which measures about 5 inches in length and is placed just below Poupart's ligament, slightly medial and parallel to the femoral artery (Fig. 372). The long saphenous vein is located and followed through the foramen ovale to the femoral vein. No collaterals of the saphenous vein which are encountered should be sacrificed in making the exposure, on account of the impending ligation of the deeper vein. The fascia overlying the vein is incised and the femoral artery is carefully retracted laterally, after division of a few small arterial branches which pass over the vein. By this time gentle palpation and inspection will have

shown whether there is thrombosis in the common femoral vein. If thrombosis is present the portion of the vein above the saphenous is exposed. On two occasions I have found a thrombus terminating just before the vein passed under the ligament. If one is positive that this is the upper limit of the clot the vein should be compressed at this point by an assistant's thumb or a tape to prevent pulmonary embolism in case there is dislodgment due to operative manipulation (Fig 373). The point of entrance of the deep femoral vein is then located and a tape

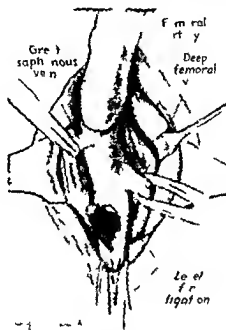


Fig 374—Operative exposure of femoral vein for removal of clot from the left femoral vein.

passed around this vessel as well as the superficial femoral and saphenous veins. The superficial femoral vein is then opened as indicated in Fig 373. If a clot is present it may be removed by milking or suction. The patency of all the venous branches is tested by momentarily releasing the pressure of the tapes. The superficial vein is then divided and securely ligated with transfusion ligatures of silk (Fig 374).

If no thrombus is palpated in the common or superficial femoral veins it has been my policy to divide the superficial

vein only Others⁹ have advised the ligation of the common femoral in this situation If there is thrombosis in the deep femoral (as evidenced by the failure of blood to flow from it when its tape is released) the common femoral had better be ligated preferably below the entrance of the saphenous If thrombosis has extended into the iliac vein a serious problem is at hand One has to choose between (1) ligation of the iliac vein by a retroperitoneal or transperitoneal approach¹⁶ (2) retrograde extraction of the clot by suction¹⁷ or (3) abandon

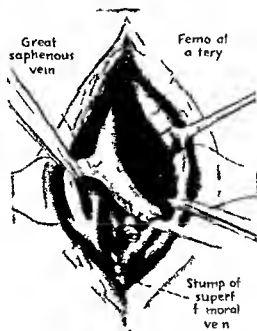


Fig 374—Ligature and division of the superficial femoral vein has been completed

ment of attempts to ligate the vein above the clot and conservative treatment with heparin or dicumarol I have been loath to do the first procedure and have been afraid to do the second for fear of breaking the continuity of a thrombus with disastrous results

Following the closure of the wound heparin and dicumarol may be given in certain cases There is apt to be some hematoma formation but this possibility has to be weighed against the danger of further thrombosis

SUMMARY

Measures for minimizing the incidence of fatal pulmonary embolism have been reviewed and described. Important among these are supervised postoperative leg exercises with deep breathing, heparinization and dicumarol therapy and femoral vein ligation with or without venography.

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SUMMARY

Measures for minimizing the incidence of fatal pulmonary embolism have been reviewed and described. Important among these are supervised postoperative leg exercises with deep breathing, heparinization and dicumarol therapy and femoral vein ligation with or without venography.

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ganglionic neurons as maintained by Smithwick Freeman White and Ascroft^{3 4 6 7} or whether regeneration of the cervicodorsal sympathetic ganglia occurs more frequently than that of the lumbar ganglia is still a matter of controversy. Nevertheless removal of the lumbar ganglia gives better and more lasting results than similar procedures in the cervico-dorsal region.

INDICATIONS

Many conditions are benefited by interruption of the sympathetic impulses in the lumbar region. One of the most important of these is *peripheral vascular disease*, in which there is vaso-spasm. There is apparently little difference in the results obtained whether the disease is purely a vasospastic one such as a vasospastic functional condition or whether there is an associated obliterative lesion as in vasospastic organic lesions of which thrombo-angiitis obliterans is an example. As emphasized by Ochsner and DeBakey^{8 9} the prognosis in a given case of peripheral arterial disease is dependent upon the degree of vaso-spasm because the therapy in a given case largely is that of relief of vasospasm. Everything else being equal the greater the degree of vasospasm and the less the organic occlusion the better is the prognosis and conversely the less the degree of vaso-spasm and the more the organic occlusion the poorer the prognosis. *Erythromelalgia* (Weir Mitchell's disease) is according to our experience not a separate entity but simply a vasospastic functional vascular disease in which the erythromelalgic phase is predominating.

In addition to spontaneous peripheral arterial disease other conditions involving the peripheral arteries are beneficially affected by overcoming vasospastic influences. Of particular importance are *acute arterial catastrophes* such as arterial injury or arterial embolism. There occurs as a result of injury to a large vessel an associated spasm not only of the involved vessel but also of the collaterals. Were it not for this protective mechanism most persons with injury to major vessels would die from hemorrhage. It has been the experience of many surgeons to observe cases in which there has been division of as large a vessel as the femoral without the occurrence of fatal hemorrhage because pronounced spasm of the artery produces hemostasis. The

writer has seen a number of butchers' injuries in continental Europe in which the femoral vessels in the upper part of Hunter's canal were injured by the accidental slipping of the knife during the process of skinning a suspended beef. Although the femoral vessels are frequently divided in such cases not infrequently simple trauma of the femoral vessels without actual penetration produces such great spasm that blood flow in the vessel is arrested. These cases usually present the symptoms and signs of complete division of the artery which before operative exploration of the site of the injury so closely simulate those of actual division that they are indistinguishable. In patients with arterial embolism the profound ischemia is due not entirely to the plugging of the main vessel by the embolus but is caused in part at least by the associated vasospasm of the collaterals. This can be easily demonstrated by the improvement in these cases following procaine block of the regional sympathetic ganglia which of course has no effect upon the clot plugging the main artery. This procedure is frequently all that is necessary to maintain viability of the extremity and to prevent gangrene thus obviating embolectomy.

As has been emphasized by Gage^{10 11} interruption of sympathetic impulses is imperative in many cases of *aneurysm* in which repair is contemplated. By so doing one need not fear subsequent ischemia. Gage has repeatedly demonstrated that even though the popliteal, external or common iliac arteries may be divided the extremity usually remains warmer and better vascularized following the operation than before obliteration of the *aneurysm*.

Ochsner and DeBakey^{13 19} have called attention to the value of interruption of the sympathetic impulses effecting rapid resolution of a *thrombophlebotic process*. If the regional sympathetic ganglia are blocked with procaine hydrochloride within four to five weeks after the onset of the process the pain, fever and swelling will rapidly subside and instead of persistence of pyrexia for weeks and continuance of the edema for months and years these patients are well within a few days.

Equally as important although less dramatic are the results obtained in long standing cases of *postphlebotic edema*. Whereas it may not seem likely that vasospasm is a factor in these cases we have been able to demonstrate repeatedly that such is the

case One must assume therefore that the thrombophlebitic segment acts as an irritative lesion and initiates vasoconstrictor impulses which are carried over the sympathetic nervous system This can be determined in a given case in the following manner The patient with postphlebitic edema is instructed to walk without any supporting bandage and at the normal rate of speed for approximately a mile Careful measurements of the circumference of the extremity are then taken usually at two levels on the thigh one at the knee and two on the leg A procaine lumbar sympathetic block is then done and after waiting about twenty minutes for the block to become complete the patient again walks the same distance at the same rate of speed Immediately upon completion of this tour measurements are again taken at the same levels If there is a decrease in the size of the extremity following the second tour one is justified in assuming that the decrease is due to the associated vasodilatation These patients are then instructed to avoid those measures which produce vasoconstriction such as smoking and exposure to cold to wear bed socks at night and to apply heat to the abdomen at night in order to produce reflex vasodilatation Generally this conservative therapy is sufficient to effect a cure Occasionally in the very severe case or in the patient in whom for economic reasons it is desirable to obtain a rapid response sympathectomy is justified

Considerable benefit can be derived from interrupting the sympathetic impulses in many cases of *post traumatic edema* in which associated with a persistent edema there is coldness and increased sweating of the extremity Also the persistence of pain following trauma in the cases of *sympatheticalgia* which in the past so often have been treated as malingering can be promptly relieved by ablation of the sympathetic impulses It is astonishing how frequently repeated blocks of the sympathetic ganglia with procaine will result in complete cure In others ablation of the regional ganglia is necessary

Congenital idiopathic megacolon or Hirschsprung's disease which does not respond to conservative therapy can be greatly improved by resection of the lumbar sympathetic ganglia Whereas it is our belief that in most of these cases resection of the second third and fourth lumbar ganglia on the left is all that is necessary occasionally bilateral lumbar ganglionectomy

is required. Contrary to our experience has been that of Telford,⁹ Ross,¹ and Oldham, who believe that bilateral denervation is always necessary. We usually resect the second, third and fourth ganglia on the left side and if the patient is relieved do not resort to resection on the right. However, we are convinced, as is Oldham, that the bilateral extraperitoneal operation is possible at one stage. Occasionally, in the extensive case it is necessary to follow the left sided resection with ablation of the sympathetic ganglia on the right.

Patients with *scleroderma* in whom there is evidence of decreased vascularity of the extremities have been successfully treated by sympathectomy. As has been previously shown by Ochsner and DeBalczyk,² not infrequently the combination of sympathectomy and subtotal parathyroidectomy is necessary to bring about a regression of the process, although occasionally simple ablation of the regional sympathetic ganglia is all that is necessary.

PROCAINE BLOCK OF THE LUMBAR SYMPATHETIC GANGLIA

As already mentioned it is possible, with few exceptions, to determine by temporary interruption of the sympathetic impulses with procaine anesthetization of the sympathetic ganglia whether operation on the sympathetic nervous system will cure the patient. In this way it is seldom necessary to resort to a destructive procedure, such as sympathetic ganglionectomy, until one is reasonably certain that beneficial results will be obtained. In many instances procaine block of the lumbar sympathetic ganglia is all that is necessary to effect a complete cure. This is particularly true in the case of thrombophlebitis in which, although the lesion is in the vein, the symptoms are entirely arterial. It is indeed an interesting biologic phenomenon that in the thrombophlebitic process there are initiated impulses which are carried over the sympathetic nervous system and produce spasm of the arterioles. This causes the pain, coldness, tightness and swelling of the extremity. These manifestations are due to arteriolar spasm and not to the venous lesion per se. This has been demonstrated both clinically and experimentally by us. Many patients with sympathetocalgia are also permanently relieved by one or several procaine blocks of the sympathetic

ganglia Frequently threatened gangrene following vascular injuries or arterial embolism can be aborted by simple procaine anesthetization of the regional sympathetic ganglia

Disadvantages of Procaine and Alcohol Block of Sympathetic Ganglia

Whereas temporary interruption of the sympathetic impulses by the injection of procaine is simple without danger of inestimable diagnostic value and frequently of great therapeutic importance it has the distinct disadvantage of producing only transient results In many instances it is permissible to follow the use of procaine with alcohol when a prolonged effect is desired At one time we were enthusiastic about the use of alcohol in the treatment of peripheral arterial disease of the vasospastic functional and vasospastic organic types However because we obtained a comparatively high incidence (15 per cent) of alcoholic neuritis of the genitofemoral nerve we have almost entirely abandoned this procedure Owing to the proximity of the genitofemoral nerve to the lumbar sympathetic chain it is difficult to understand why this does not occur more frequently Alcoholic neuritis of the genitofemoral nerve produces a pronounced hyperesthesia of the upper medial aspect of the thigh and the adjacent genitalia and is at times most disabling Where as there may be some indication for the use of alcohol it is our belief that if a prolonged interruption of sympathetic impulses is desired it is far better to do a sympathectomy which is a procedure that carries virtually no risk and little disability except that there is a possibility of the development of an alcoholic neuritis

Technic of Procaine Block of Sympathetic Ganglia

The technic of lumbar sympathetic procaine anesthetization is extremely simple and is one that should be mastered by every surgeon Whereas it is somewhat easier to anesthetize the lumbar sympathetic ganglia with the patient in the prone position not infrequently particularly in the patient with acute phlegmasia alba dolens who is too ill to be placed in this position it is necessary to use the lateral decubitus position (Fig 375 a) Aside from the position in these different types of cases the technic is exactly the same If the prone position is employed it is desirable to straighten the spinal lumbar curve by placing

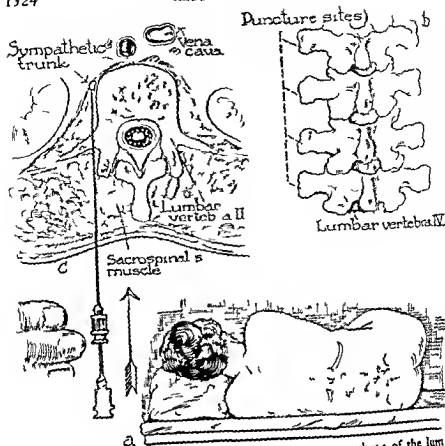


Fig 375.—Diagram showing the technique of procaine anesthesia of the lumbar sympathetic ganglia

a The lateral decubitus position is used in patients who are too ill to be placed in the prone position. This is the position usually employed in patients with thrombophlebitis.

b Points are chosen two fingerbreadths lateral to the spinous processes of the first, second, third, and fourth lumbar vertebrae. The spinous processes are chosen because they are at approximately the same level as the transverse processes.

c The transverse process of the lumbar vertebra serves as a landmark for the introduction of the needle because whereas there may be considerable variation in the thicknesses of the sacrospinal muscle and the subcutaneous fat of an obese muscular man and of a small emaciated man, there is relatively little difference in the thicknesses of the bodies of the vertebrae. The needle is introduced at a point two fingerbreadths lateral to the spinous process perpendicular to the skin until it is pointing against the transverse process. The point of the needle is then changed slightly either upward or downward and the needle is introduced for an additional two fingerbreadths. The needle point then lies in the retroperitoneal space on the anterolateral surface of the vertebral body where the sympathetic chain is located. Through each of the four ports first, second, third, and fourth 5 cc of 1 per cent procaine are injected.

pillows beneath the abdomen of the patient (Fig 376) Since the spinous processes of the lumbar vertebrae are horizontal (Fig 375 *b*) and not directed caudally as those of the thoracic vertebrae are they may be used as landmarks for the transverse processes The transverse process of the vertebra is the landmark chosen to determine the depth of the injection The reason for this is that although there may be considerable difference in the thicknesses of the subcutaneous fat and the sacrospinalis muscles in the obese muscular man and in the thin emaciated woman there is relatively little variation in the thickness of the bodies of the respective vertebrae (Fig 375 *c*)

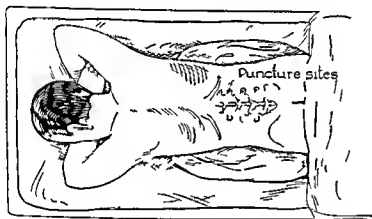


Fig 376—Diagram showing the prone position which is used for procaine anesthetization of the lumbar sympathetic ganglia when the patient is not very sick. This position is somewhat easier than the lateral decubitus (Fig 375 *a*). The lumbar spinal curvature is straightened by placing pillows beneath the abdomen. Otherwise the technic is exactly the same as shown in Figure 375.

A cutaneous wheal is made two fingerbreadths lateral to the spinous processes of the first second third and fourth lumbar vertebrae. At the site of each wheal a fine (No. 22) lumbar puncture needle is inserted perpendicular to the skin. The needle is introduced until it strikes the transverse process. Its direction is then slightly changed either upward or downward so that it may be pushed beyond the process for an additional two fingerbreadths (Fig 375 *c*). The point of the needle then lies in the retroperitoneal space on the anterolateral surface of the bodies of the vertebrae where the sympathetic chain is located. Through each one of these four ports the first second third and fourth 5 cc of 1 per cent procaine are injected.

This floods the retroperitoneal area and thus anesthetizes the sympathetic ganglia. Complete anesthetization usually requires twenty to thirty minutes.

Determination of the Result of Procaine Block of Lumbar Sympathetic Ganglia

Whether procaine anesthetization of the lumbar sympathetic ganglia produces the desired results is determined in a number of different ways depending upon the condition which is being treated. In peripheral arterial disease one can use either oscillometric, plethysmographic or colorimetric methods to determine the increase in blood supply. Also the functional effect is of importance. If a patient suffers from intermittent claudication before the block, it is important to determine whether he is able to walk a greater distance without pain after the sympathetic block. Increased warmth, decreased sweating, increased arterial pulsation and increased arteriolar pulsation are evidences of increased blood flow. In patients with sympathetalgia the prompt subsidence of pain following the completion of the block is of diagnostic importance. In congenital idiopathic megacolon not infrequently there results an evacuation of the colon following the completion of the block and generally one can demonstrate roentgenographically by means of barium enema a decrease in the diameter of the bowel. In scleroderma obviously little or no result can be observed following the procaine anesthetization of the sympathetic ganglia except that the extremity becomes warmer and drier.

In both postphlebitic edema and post-traumatic edema the size of the extremity decreases following the increase in vascularity obtained by sympathetic block. Definite improvement in circulation is noted in peripheral arterial injuries and in arterial embolism. In addition to the improvement of the circulation of the extremity in arterial aneurysm not infrequently is emphasized by Gage^{10, 11} there is a decrease in the size of the aneurysm which is due to the decrease in the peripheral resistance. Sympathectomy in such an instance exerts not only a desirable effect on the collaterals but has a very definite beneficial effect on the aneurysm itself. We have repeatedly observed cases in which following sympathectomy the aneurysm apparently has been completely obliterated because of the de-

crease in the tension within the sac which has permitted clotting

LUMBAR SYMPATHETIC GANGLIONECTOMY

Sympathectomy is indicated if permanent interruption of the sympathetic impulses is desired. Whereas many approaches have been suggested for ablation of the lumbar sympathetic ganglia we are convinced from extensive experience in which many types of incisions and approaches have been utilized that the anterolateral extraperitoneal approach is the one of choice. We prefer a modification of the approach suggested by Leriche⁴ which differs from the latter in that it is a muscle splitting incision which permits early ambulation of the patient. Moreover many of our patients are out of bed on the second postoperative day and practically all of them are up on the third. Most of them leave the hospital on the fifth day. Because of early ambulation, short hospitalization and the safety of lumbar sympathetic ganglionectomy when performed in this way we prefer ablation of the ganglion to alcoholic injection when a prolonged effect is desired. Not only is the effect much more complete and more prolonged but also the possibility of alcoholic neuritis which occurs in about 15 per cent of instances is obviated.

Technic

Lumbar sympathetic ganglionectomy is performed in our Clinic in the following manner. Lumbar analgesia is preferable to inhalation anesthesia because the relaxation which is obtained facilitates performance of the operation and makes the convalescence smoother. With the patient in the supine position low pillows are placed beneath the shoulder and hip of the side to be operated upon to elevate it a little (Fig. 377 *a*). A slightly curved incision with the concavity medially begins just lateral to the outer border of the rectus and slightly below the costal margin and extends downward to end just lateral to the lateral border of the rectus on a level with the anterior superior iliac spine (Fig. 377 *b* and 378 *1*). This incision extends through the skin, subcutaneous fascia and fascia of the external oblique muscle. The fascia of the external oblique muscle is freed from the underlying internal oblique muscle for a distance of from 10 to 12 cm. The internal oblique and transversalis muscles are

surface of the bodies of the vertebrae. On the right side of the chain lies deep to the vena cava whereas on the left it is located beneath the aorta. When these respective vessels are retracted medially, care must be taken not to injure them (Fig. 380). Occasionally it is necessary in extremely muscular persons to retract the iliopsoas muscle laterally because the sympathetic

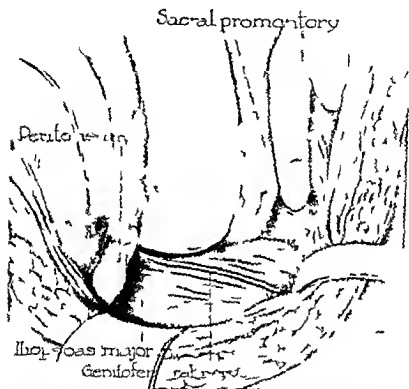


Fig. 379—Diagram showing exposure of the iliofemoral and the genitofemoral nerve crossing, by retraction of the peritoneum medially. The sacral promontory is easily identified in the lower part of the fund and is an important landmark because it is at this level that the fourth lumbar ganglion is found.

chain may be partly covered by it. For this we prefer a dissector which is a compact piece of gauze held in the tip of a long curved forceps.

It is imperative that the field be bloodless because if there is any bleeding it is impossible to recognize the sympathetic chain. In the bloodless field however the chain can be both

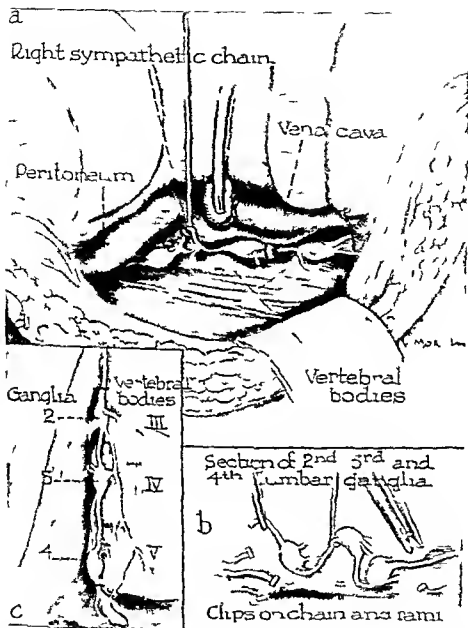


FIG. 380-a The sympathetic chain is exposed in the angle between the bodies of the vertebrae and the iliopsoas muscle. The vena cava on the right and the aorta on the left are retracted medially. By means of hooks the chain is picked up and with the ganglia and rami is dissected out. Care must be taken not to injure the lumbar arteries and veins which cross over the sympathetic chain.

b By means of silver clips the rami and chain are compressed before division. This is of importance to prevent hemorrhage from small vessels which usually accompany the fibers.

c Generally the second, third and fourth lumbar ganglia are removed, the chain being divided above the second and below the fourth. Occasionally in cases of postphlebotic edema in which there is swelling of the thigh it is necessary to remove the first ganglion. This is undesirable however in the male particularly because of interference with ejaculation when done bilaterally.

palpated and seen on the anterolateral surface of the bodies of the vertebrae. By means of hooks the chain is grasped and elevated (Fig 380 a). With additional dissectors the ganglia and rami are dissected out. Care must be taken not to injure the lumbar arteries and veins which emerge from and enter the aorta and vena cava respectively and which cross over the sympathetic chain. After isolation of each individual ramus it is clamped with a silver clip because usually there is a small vessel accompanying the ramus which may bleed if it is divided without previously clipping it (Fig 380 b).

Generally the second, third and fourth lumbar ganglia are removed (Fig 380 c) although occasionally it is necessary to remove the first particularly in the patient who has a post phlebotic edema involving the upper part of the thigh. It is desirable however not to remove the first when this is not necessary particularly in the male because bilateral ablation of the first ganglia prevents ejaculation and produces sterilization. The fourth sympathetic ganglion lies opposite the promontory of the sacrum which makes it readily recognizable. The sympathetic chain is divided above the second and below the fourth when the second, third and fourth are removed (Fig 380 c). Generally the entire operation can be done without any bleeding whatsoever and can be completed within a short period of time. For the past four years we have used nothing but cotton throughout ligating the small vessels in the skin and subcutaneous fascia with No. 80 cotton.

After resection has been completed the retractors and packs are removed allowing the peritoneum to fall back. The transversalis and internal oblique muscles are approximated by several loosely tied quilting cotton sutures. The fascia of the external oblique is carefully approximated by interrupted sutures of quilting cotton and the superficial fascia is similarly approximated. The skin is closed either with a continuous interlocking quilting cotton suture or interrupted sutures. For the past year and a half we have used the Singer Surgical Stitching Machine which is of great value in using nonabsorbable sutures because it greatly facilitates the use of interrupted sutures. The machine is particularly useful when cotton is employed. After a sterile dressing has been placed over the wound a compression bandage with mechanics waste is applied. This is used routinely on all

wounds in our clinic and is undoubtedly partly responsible for the excellent healing which we obtain

SUMMARY

Patients with disturbances of sympathetic innervation can usually be informed preoperatively whether sympathectomy will benefit them. This can be predicted simply by temporary interruption of the sympathetic impulses with procaine anesthesia of the sympathetic ganglia. Ablation of the sympathetic ganglia is indicated in peripheral vascular diseases, arterial catastrophes, certain cases of aneurysms, acute and chronic thrombophlebitic processes, congenital idiopathic megacolon and scleroderma. The technique of procaine block and lumbar sympathetic ganglionectomy are described in detail.

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SURGICAL TREATMENT OF SCIATICA DUE TO RUPTURE OF AN INTERVERTEBRAL DISK*

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ALTHOUGH it is now generally conceded that the principal cause of chronic sciatic pain is an intraspinal rupture of the fourth or fifth lumbar intervertebral disk, both orthopedic surgery and neurological surgery became mature specialties before this disease was understood. Occasional reports of traumatic intraspinal rupture of a disk appeared in the literature (Kocher¹ in 1896, Middleton and Teacher² in 1911, Goldthwaite³ in 1911, Dandy⁴ in 1929) but it was not until 1934 that Mixter and Barr established sciatic pain due to ruptured disk as a clinico-pathological entity. During the ensuing nine years the diagnosis and surgical treatment of this condition have steadily evolved so that many thousands of cases are successfully treated each year. A historical review of the subject can be found in the monograph *The Intervertebral Disk* by Bradford and Spurling.⁵

DIAGNOSIS

The diagnosis of sciatica due to protrusion of an intervertebral disk is easy to make in certain respects and difficult in others. The fundamental factor in establishing the diagnosis is the patient's *detailed description of the pain and associated symptoms*. The pain is located in the posterolateral aspect of the thigh and leg. Frequently pain extends to the ankle, foot and toes. Usually the patient also experiences pain in the hip, buttock and sacro-iliac and lumbosacral regions. Often the pain in the back or hip is far more severe than the pain in the leg.

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Coughing sneezing bending and lifting exaggerate the pain in the back or hip and may cause it to radiate all or part of the way down the lower extremity. The patient is forced by the pain to limp. Should the nerve root be sufficiently compressed by the protruding portion of the disk numbness tingling and other abnormal sensations in the leg foot or toes are experienced. Occasionally slight weakness of the ankle is mentioned.

In a typical advanced case the diagnosis is practically established by the patient's description of the symptoms but other factors are important particularly the *history*. Chronicity of symptoms is an outstanding feature in most of the patients who are candidates for surgical treatment. Intermittent and often of many years duration the pain in the back precedes the pain in the leg by weeks months or years. Frequently the pain in the back subsides or disappears when the sciatic pain begins. The sciatic pain may also be intermittent occurring only in attacks of several months duration.

Although the history of an injury to the back is of value in arriving at the diagnosis the absence of such a history is of no significance whatsoever. In fact less than half the patients with this disease attribute the pain to trauma.

In three fourths of these patients the sciatic pain is strictly unilateral. In the remaining one fourth there is a lesser pain in the other buttock and leg. Severe bilateral sciatica or alternating sciatica can be caused by a ruptured disk but the differential diagnosis is more complicated.

Thus the patient's description of the symptoms and the details of the history are all that are needed to establish a tentative diagnosis in the great majority of cases. However additional precautions are required if negative explorations of the spinal canal are to be avoided.

Most helpful in establishing the diagnosis is the *combined orthopedic and neurologic examination*. Diminution or absence of the Achilles reflex on the side of the sciatica is strongly indicative of the diagnosis and suggests that the fifth and not the fourth disk is the affected one. Normal Achilles reflexes are entirely compatible with the diagnosis of ruptured disk. Inequality of the patellar reflexes or absence of one of them casts considerable doubt on the diagnosis of rupture of the fourth or fifth lumbar disk. Sensory examination of the leg and foot with

a pin point cotton heat and cold is not important but occasionally discloses some tactile loss of which the patient was not aware. There is never anesthesia but merely areas of disturbed or diminished sensibility. Sensory changes on the big toe and the adjacent toe indicate that the fourth disk is at fault. Disturbance in the fourth and fifth toes points to rupture of the fifth disk.

Limitation of movements of the back, muscular spasm producing loss of lumbar lordosis and spasm causing list of the lumbar spine toward or away from the side of the sciatica all tend to verify the diagnosis and to differentiate the condition from toxic or inflammatory neuritis of the sciatic nerve. Limping and pain on straight leg raising are constant findings. In the majority of cases when the examiner presses firmly on the fifth lumbar spinous process or 1 inch lateral to it the patient complains of local tenderness and exaggeration of the sciatic pain. This is a most reassuring sign.

It is wise to have *roentgenograms* of the lumbar spine to eliminate a diagnosis of spondylolisthesis, spondylolysis, fracture of a pedicle, primary bone tumor and metastatic carcinoma since each of these conditions can produce a syndrome closely resembling ruptured disk. In most cases of ruptured disk films of the spine are normal, a point which helps to verify the diagnosis of ruptured disk. In some cases there is narrowing of the affected disk, but this is a treacherous finding, as the narrowed disk may not be the one that has ruptured into the spinal canal. Congenital anomalies in the lumbosacral region, including spina bifida occulta, are occasional findings in cases of ruptured disk. Hypertrophic arthritis rarely imitates the syndrome of sciatica due to ruptured disk and its presence in no way casts doubt on the diagnosis.

Examination of the spinal fluid in typical cases of sciatica due to herniated disk is of little value. The only finding is an increase in the total protein content which is present in only 50 per cent of cases. Syphilis does not mimic the syndrome of ruptured disk and its presence merely adds another therapeutic problem.

When the surgical treatment for ruptured intervertebral disk was in its infancy the custom was to verify the diagnosis by *myelography*. This procedure consists in the injection of from

2 to 5 cc of lipiodol into the lumbar subarachnoid space to permit visualization of the dural sac with the fluoroscope. By tilting the table the radiologist can watch the radiopaque oil as it flows up and down in the lumbar region. Intraspinal rupture of a disk causes a filling defect in the dural sac. Myelography with lipiodol would probably still be in routine use had not certain objections arisen. Chief among these is the fact that lipiodol cannot easily be removed (except at operation) and remains permanently in the dural sac. Air myelography next was tried but did not prove to be reliable. The latest method, myelography with pantopaque (a thin iodized oil) promises to be almost entirely satisfactory. Injection of this substance is made into the lumbar subarachnoid space with the patient in the prone position on the fluoroscopic table. The needle is left in place during the fluoroscopy. After the ruptured disk has been visualized and a roentgenogram made it is possible to aspirate the iodized oil by attaching a syringe to the needle, a procedure which was difficult to accomplish with the thicker lipiodol.

In spite of the existence of this satisfactory method of demonstrating roentgenologically a rupture of a lumbar disk, it is not popular with neurosurgeons as a routine procedure because they know that the clinical diagnosis is infallible in typical cases; therefore myelography is usually reserved for complicated or atypical cases.

SURGICAL TREATMENT

Evolution of the Operation for Ruptured Disk

Early in the development of the surgical treatment for herniated disks it was necessary to remove several spinous processes and laminae before attempting to locate and resect the protruded portion of a disk. At present it is customary to remove the lesion without doing a complete laminectomy. The spinous processes need not be disturbed and only small parts of the laminae are removed.

A second refinement in technic came with the abandonment of the transdural approach to a ruptured disk. Formerly laminectomies were too narrow and the extradural approach to a lesion near the midline did not seem feasible. Now it is possible

to remove any type of ruptured disk without opening the dura. Because of the danger of producing arachnoidal adhesions the dura should not be opened even to extract lipiodol.

A third advancement appeared with the realization of the importance of adequate unroofing of the compressed nerve root. This measure insures against recurrence of the sciatica and has abolished the practice of sectioning the sensory fibers of the nerve root.

A fourth improvement in the early operation is curettement of the interior of the disk after the extruded portion has been removed. This procedure gets rid of the free or loosely attached fragments occupying the central portion of the degenerated disk and makes further herniation unlikely.

The final important technical advance is the combination of spinal fusion and removal of the disk in a single operation in those patients who are certain to have residual pain in the back if the disk operation alone is performed. The orthopedic surgeon and the neurosurgeon participate in this operation.

Preoperative Preparation

On the day before operation the lower half of the back is shaved and an enema is given if the patient has not had a spontaneous bowel movement on that day. A good night's rest is assured by means of pain relieving and sleep inducing drugs. One fourth grain of morphine is given one hour before operation.

Anesthesia

The choice of anesthetic is not of great importance. Spinal, regional and general anesthetics are in common use. However, regional anesthesia is advantageous in that it usually permits identification of the lesion before the surgeon begins to remove the ligamentum flavum and bone. By means of regional anesthesia (1 per cent procaine hydrochloride with 3 drops of adrenalin per ounce) the spine can be painlessly exposed and the ligamentum flavum partially removed. However, as soon as an instrument is placed near the compressed spinal nerve root intense sciatic pain is felt. At this point the root should be injected with procaine hydrochloride by means of a hypodermic needle. In rare instances the nerve root is so placed that

it cannot be exposed and injected without producing intense pain. Under these circumstances it becomes necessary to give pentothal intravenously for about five minutes or to give an inhalation or spinal anesthetic for the remainder of the operation. A small amount of spinal anesthetic can of course be injected directly into the exposed dural sac. One disadvantage of a regional anesthetic is that in large patients it does not provide adequate relaxation of the spinal muscles.

Technic of Partial Hemilaminectomy for Rupture of Fifth Lumbar Disk

The patient is placed in the prone position on the operating table. It is desirable to straighten the normal lumbar curvature by breaking the table and flexing the hips or by placing a pillow under the abdomen or by combining these (Fig. 381 *a*). The latter method has the disadvantage of increasing intra-abdominal pressure and consequently venous congestion within the spinal canal. After the skin has been prepared, the fifth lumbar spinous process is palpated and marked by a small cross made with the scalpel. Using the cross mark as the center, an area of skin 2 inches wide and 6 inches long is marked off with towels which are fastened to the skin with clips or sutures. Additional draping is completed after which an incision 4 to 6 inches long (depending on the size of the patient) is made in the midline over the lower two or three lumbar spinous processes and the upper part of the sacral crest (Fig. 381 *b*). Bleeding is controlled by hemostats and electrocoagulation. The midline incision is continued down through soft tissue to the bony tips of the lumbar and sacral spinous processes. By means of a periosteal elevator and a certain amount of sharp dissection, the muscles and periosteum are retracted from the right or the left sides of the spinous processes, depending on the location of the sciatica (Fig. 381 *c* and *d*). Bleeding during this stage is temporarily controlled by packing the wound with gauze sponges. After the muscles and periosteum have been scraped from the spinous processes and the corresponding laminae of the fourth and fifth lumbar vertebrae and the upper part of the sacrum, one or two self-retaining retractors are inserted. Bleeding points are then picked up with the metal sucker which is in turn touched with the electrocoagulator. Loose strands of muscle and ligaments are removed from the field. A satisfactory exposure of the lum-

bosacral interspace and the interspace between the fourth and fifth lumbar laminae is thus obtained

The following manipulations are performed when doubt exists as to which disk is ruptured The spinous process of the

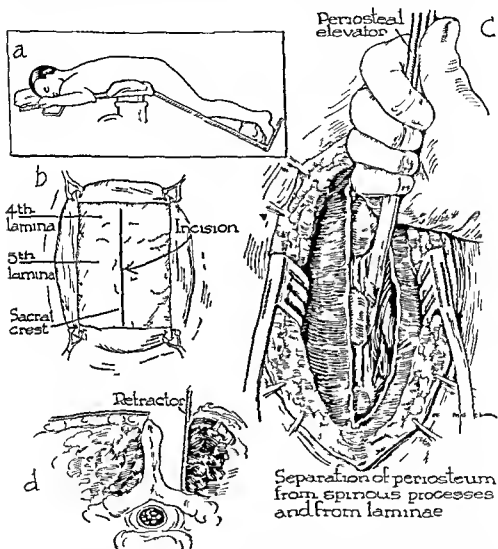


Fig 381—*a* Maximum flexion of the lumbar spine facilitates the performance of laminectomy *b* A median line skin incision is centered over the fifth spinous process *c* After the fascia has been incised the periosteum is scraped from the lateral aspects of the spinous processes and laminae on one side as is also illustrated by cross section in *d*

fifth lumbar vertebra is grasped with a heavy forceps and moved caudad and cephalad The fourth spinous process is similarly moved If the fourth disk is ruptured there will be increased

mobility of the fourth and fifth spinous processes when they are pushed toward each other. Rupture of the fifth disc causes abnormal mobility of only the fifth spinous process. By this procedure the surgeon usually can determine which of the two

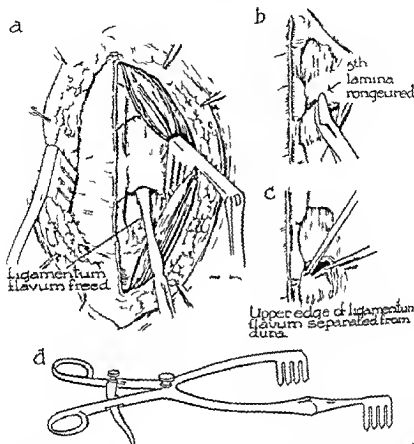


Fig. 38.—a A curved pair of retractors is of a large size in separating the ligamentum flavum from its attachment to the anterior and inferior surface of the fifth lamina. b The inferior edge of the fifth lamina is retracted with the rongeur forceps. A adequate exposure has been attained with a pair of self-retaining retractors that has one long and one short arm as shown in d. c Forceps grasps the freed cephalad edge of the ligamentum flavum which is removed by sharp dissection.

disks should be explored. If the operation is being done under a local anesthetic additional verification can be obtained in the following manner. The ligamentum flavum connecting the fifth lamina with the sacrum is forcefully palpated with a blunt in-

strument This usually reproduces the sciatic pain if the lesion is at that level If the finding is negative the manipulation is repeated at the interspace between the fourth and fifth laminae There is no need for palpation of the ligament between the third and fourth laminae since the third lumbar disk rarely ruptures and when it does it can invariably be anticipated clinically and should be verified by myelography

After the diagnosis of herniated fifth disk has been made the next step is to open the spinal canal By means of a curved periosteal elevator the attachment of the ligamentum flavum is forcefully separated from the undersurface of the fifth lumbar lamina (Fig 382 *a*) The caudad edge of this lamina is then removed with the rongeur (Fig 382 *b*) this brings the free cephalad edge of the ligamentum flavum into view The ligamentum flavum can then be removed with a forceps and scissors or knife (Fig 382 *c*) One fourth inch of the first sacral lamina is also removed thus providing an opening about one inch in length through which the dural sac can be seen

Next the floor of the spinal canal should be palpated by compressing the dural sac with the finger This does no harm to the few nerve roots within the dural sac at this level The majority of ruptured disks protrude sufficiently far into the spinal canal so that they can be palpated However a negative exploration is not complete until the dural sac and the first sacral nerve root have been retracted to expose the disk from the midline to the intervertebral foramen

As soon as the extruded portion of the disk (disk nodule) has been palpated attention is directed to exposing the nerve root This may be the most difficult part of the operation since the root may be tightly wedged between the disk nodule and the bone and ligament forming the lateral wall of the spinal canal To avoid damage to the incarcerated root the bone is sometimes removed with a small chisel (Fig 383 *b*) The exposure is completed with a bone cutting punch (Fig 383 *c*) It is important to unroof the pinched nerve completely This procedure alone would undoubtedly terminate the sciatic pain in many cases

The next step of the operation is to expose and remove the disk nodule but first it is necessary to retract the root and the dural sac medially (Fig 384 *a*) The lesions thus brought into

view vary in appearance and character. The commonest type is a smooth yellowish hemispherical nodule which feels rubbery on palpation. This appearance is largely due to the nodule being fixed in place by a tight capsule. Incision with a pointed knife may cause eruption of the loose contents through the opening (Fig 384 *b*). At times the contents are firmly attached

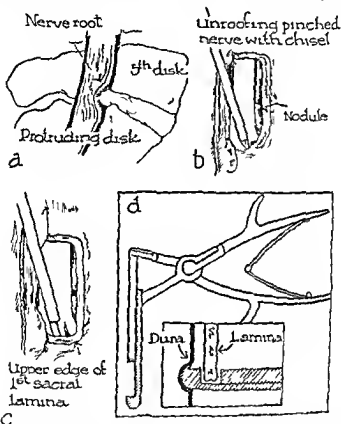


Fig 383—*a* Diagram showing pressure by herniated disk upon the dura and first sacral nerve *b* Removal of the neural capsule *c* The pinched nerve root *d* The opening into the spinal canal is enlarged by means of a bone cutting punch (shown in *d*) that bites off the lamina at right angles

within the disk and must be forcefully pulled out. Herniated tissue is made up of fragments of annulus fibrosus and the remains of the nucleus pulposus. Occasionally an unencapsulated mass of extruded disk tissue is encountered and is simply lifted or pulled out. The third type of ruptured disk frequently found is the bulging or concealed rupture. Such a lesion

is large and relatively flat, especially if the patient is in the flexed position. During weight bearing it protrudes sufficiently to compress the nerve root. Upon palpation with an instrument a soft disk is felt in contrast to the firmness of a normal disk. Moreover a normal disk is always hidden by a plexus of veins

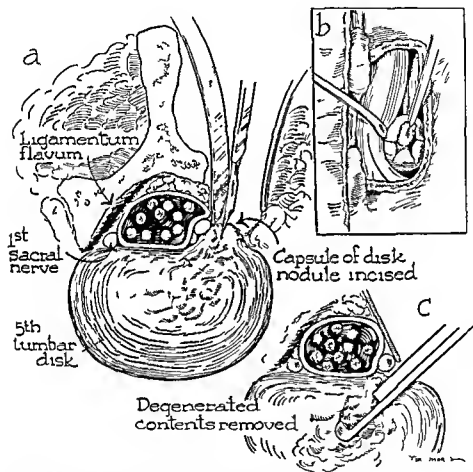


Fig. 384—*a* The nerve root and dural sac have been retracted to expose the disk nodule the capsule of which is opened by a stellate incision *b* The contents of the disk nodule are removed with forceps *c* By insertion of an instrument into the center of the disk the loose contents are extracted

This type of lesion should be incised so that the loose degenerated contents of the disk can be removed. The surface of this lesion is the posterior longitudinal ligament and the intact outer ring of the annulus fibrosus. It will be found that all of the deeper rings of the annulus are ruptured.

Regardless of the type of intraspinal lesion which has been

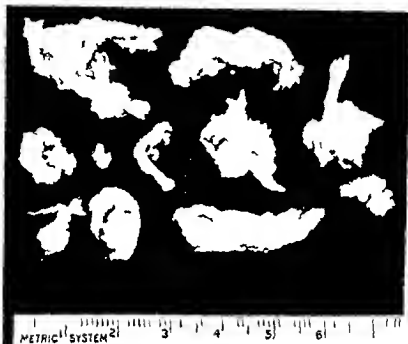


Fig. 385—Photograph of the numerous fragments of disk located by computer graphic method after a fall generated fall.

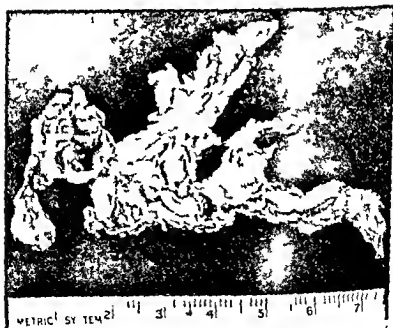


Fig. 386—Fluorograph of an unusually large fragment of vertebral body as partly inside the spinal canal and partly within the disk.

removed the final step is to expose the fissure in the disk through which the herniated cartilage has escaped. The opening is usually large enough to permit insertion of a bone punch, curette or pituitary forceps into the interior of the disk (Fig 384 c). If necessary the opening can be enlarged. The condition of the interior of the disk varies greatly depending chiefly on the time that has elapsed since the tearing of the annulus fibrosus and the escape of the gelatinous nucleus pulposus. In cases of recent rupture the interior of the disk is firm and resilient. In cases of long duration the disk has lost its turgor and there may even be a large cavity in its center. Curettage may bring forth many loose fragments of tissue (Fig 385). Occasionally a large part of the disk has become separated and can be pulled out (Fig 386). It is usually wise to remove as much of the degenerated interior of the disk as possible but the intact portions of the disk should not be disturbed.* The writer routinely leaves a small metal clip in the center of the degenerated disk for future identification since the site of a small partial hemilaminectomy might otherwise be undetectable by roentgenography.

Complications During Operation

Unless special care is taken the dural sac may be torn or cut with the bone cutting instruments. Suture of a tear in the dura may be impossible through a partial hemilaminectomy in which event a small section of crushed muscle may be used as a plug. By accident the bone punch has also been known to crush or sever the nerve root and cause slight permanent anesthesia and weakness of the foot. When there is doubt as to the exact location of the nerve a chisel should be used in unroofing it.

The chief complication of this operation is the inadvertent production of severe bleeding from the venous plexus which lies anterior to the dural sac and the nerve roots. Surgeons unfamiliar with this region have been forced to abandon the operation after tearing one of these veins. It is most important to

Other methods of dealing with the diseased disk have been advocated. Some have driven a fragment of bone into the cavity of the disk in order to stabilize it. I have not tried this. However in twelve recent cases I have used a curette to break through the cartilage plates and vertebral cortices which separate the disk from the cancellous bone of the adjacent vertebral bodies. Whether or not this leads to vascularization and eventual filling in of the disk cavity with connective tissue remains to be seen.

retract the nerve root and dural sac with great care. Although it is true that these veins do not overlie a disk nodule, they are to be found around the periphery of the lesion. Bleeding occurring near the nodule may be controlled by small packs of moist cotton to each of which is attached a long suture. If the veins continue to bleed after the cotton has been removed, a section of crushed muscle can be used as a permanent pack. To avoid the possibility of hemorrhage, veins close to the base of a disk nodule may be obliterated by electrocoagulation.



Fig. 387.—Exploration of the fifth disk has disclosed no abnormality, but a lesion of the fourth disk is revealed after further exploration.

Completion of Operation

It is wise to irrigate the wound several times with warm saline solution in order to get rid of fat droplets, dry blood and fragments of tissue. There is no objection to using a small amount of sulfanilamide in the cavity. The first line of sutures (cotton) is in the fascia, which is attached to the tips of the spinous processes of the vertebrae. The remaining layers are also closed with interrupted cotton sutures.

Rupture of Fourth Lumbar Disk

A rupture of the fourth lumbar disk is removed in exactly the same way as a lesion of the fifth disk but the operation is somewhat more difficult because (1) the lesion is farther from the surface of the back (2) the lamina of the fourth disk is not as long as that of the fifth and (3) the root bears a slightly different relation to the disk

The surgeon may explore a disk that proves to be normal particularly when a spinal or general anesthetic is used

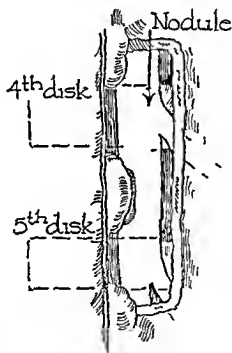


Fig 388—By this method both the fourth and the fifth disks may be exposed
The fifth lamina has been removed

Through a separate opening he may then expose the other disk (Fig 387) It is possible to explore both the fourth and fifth disks and still leave the bony ring of the fifth vertebra intact This is especially desirable if a spinal fusion is to be done at the same time However if spinal fusion even at a later date is not anticipated there is no objection to removing the rest of the fifth lamina as shown in Figure 388 This saves time and trouble and insures an adequate unroofing of the fifth lumbar root

Bilateral Laminectomy

Up to this point attention has been given strictly to the unilateral approach to the fourth and fifth intervertebral disks. This technic of retracting the muscles from only one side of the posterior spinous processes diminishes the postoperative back pain and enables the patient to walk at an earlier date. However there is no real objection to bilateral exposure of the laminae which facilitates performance of the operation particularly if special retractors for the unilateral approach are not available.

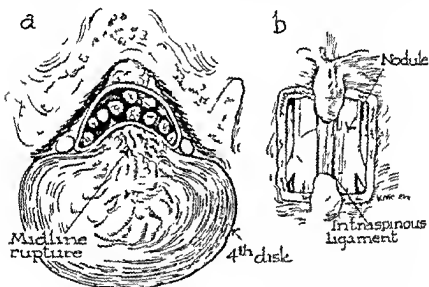


Fig. 389—*a* Rupture of intervertebral disk causing bilateral sciatic pain. *b* Bilateral partial laminectomy with removal of spinous processes and intraspinal ligament in a patient with bilateral sciatic pain. The disk nodule is removed from the side on which the pain is more severe. The bilateral exposure assures adequate decompression of both nerve roots.

In addition to this practical consideration the bilateral exposure and bilateral laminectomy are often indicated in patients who have bilateral sciatic pain. In such cases it is assumed that the patient has a rupture of the disk near the midline which is large enough to cause pressure on the roots of both fifth lumbar or both first sacral nerves (Fig. 389 *a*). Since such a lesion usually occupies more space on one side than on the other the sciatic pain on one side is usually milder. Exposure of this type of lesion is made on the side of the greater pain through

an opening made by hemilaminectomy or partial hemilaminectomy. If the entire midline protrusion cannot be removed by this route a partial hemilaminectomy is performed on the other side (Fig. 389 *b*). This permits unroofing of both nerve roots and is good insurance against the persistence of sciatic pain on the lesser side. Of minor consideration is the fact that the spinous processes and connecting ligaments may be left intact. However, there is no serious objection to removing or partially removing two spinous processes and the connecting ligaments.

Postoperative Care

The patient is placed on his back in bed with a pillow under the head. After six hours he may lie in any position. Morphine is prescribed freely for several days. Catheterization is necessary once or twice in many cases, particularly if a spinal anesthetic has been used. An enema is permitted on the second or third day. On the second postoperative day the patient may choose his own diet. He is allowed to sit up in bed and then in a chair after the first week if he is free of pain. The usual hospital stay is twelve days.

Combined Disk Operation and Spinal Fusion

Combined operation for removal of the herniated portion of the disk and spinal fusion should be performed in about 14 per cent of all cases of ruptured disks.⁷ The decision to perform spinal fusion is made by the orthopedic surgeon from the history, clinical findings, roentgenograms and occupation of the patient. If an unstable back can be demonstrated clinically and roentgenographically, if pain in the back is the major complaint and can be relieved by immobilization, and if the patient must return to strenuous labor, it is prudent for the orthopedic surgeon to fuse the spine at the same time that the neurosurgeon terminates the sciatic pain. Because of the long period of time required, it is preferable to perform the combined operation under a spinal anesthetic. This may be administered fractionally, since the dorsal sac is exposed at operation, permitting the injection of additional anesthetic solution through a hypodermic needle. The orthopedist assumes charge of the patient as soon as the intraspinal lesion has been removed.

RESULTS OF OPERATION

Prior to June 1943 the writer operated on 170 patients with sciatica who were presumed to have a rupture of an intervertebral disk. Spinal fusion by an orthopedic surgeon was carried out at the same time in seventeen of the last 100 cases. The results in the first fifty cases have already been reported.⁸ Follow up studies on the remaining patients have been made and will appear elsewhere. Some poor or indifferent results were obtained in the first part of the series due to inadequate operation or incorrect diagnosis. In the last 100 cases the results in general can be described as excellent. In the entire series there was one postoperative death in a man aged fifty years who had a combined spinal fusion and removal of a disk nodule. Autopsy disclosed an embolus in the pulmonary artery, presumably from unrecognized thrombophlebitis of the leg. There were one superficial wound infection and two deep infections. Both of the latter were treated by laminectomy and open drainage.

The infrequency of negative explorations in the last 100 cases is attributed to close collaboration with orthopedic surgeons. Paradoxically, the majority of negative explorations were performed at the request of orthopedic surgeons. In these instances the primary operation was lumbosacral fusion for back pain and the disk inspection was carried out as a precaution against overlooking a ruptured disk which might be causing the associated atypical sciatic pain.

SUMMARY

It is firmly established that chronic sciatic pain is chiefly caused by intraspinal rupture of the fourth or fifth lumbar intervertebral disk. The fundamental factors in determining the diagnosis are the patient's detailed description of his symptoms, the history, the clinical examination and the roentgenograms of the spine. The diagnosis can be verified by myelography with pantopaque but this procedure is not routinely necessary.

The surgical treatment of ruptured disk has evolved from a complete laminectomy with transdural removal of the disk to extradural removal of the disk by means of a partial hemilaminectomy. The technique of partial hemilaminectomy hem

laminectomy and bilateral hemilaminectomy are described in detail

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USE OF PRESSURE DRESSINGS IN THE TREATMENT OF BURNS AND OTHER WOUNDS*

NEAL OWENS MD FACST†

ALTHOUGH pressure dressings have been used routinely many years a satisfactory one has been developed only after careful evaluation and analysis over a long period by surgeons keenly interested in the treatment of wounds. According to Blair¹ the use of pressure over various types of bandages has been practiced since the earliest application of protective dressings over wounds. Probably the first to place proper emphasis on the value of pressure dressings Blair in 1924 stated "The application of most any dressing produces pressure but he who employs this pressure in a selective purposeful manner will get bigger returns than he who applies it incidentally or even as a matter of routine. He called attention to the necessity of external pressure for the actual life of the body and the proper functioning of its organs. Of the value of pressure on the healing and reparative processes he wrote — artificial pressure has long been recognized as one of our most important resources therefore we use the truss or the abdominal binder to compensate for a hernia or bandage the legs for varicose veins or for lymph stasis. In the healing of wounds it is one of the great helps which we may add to the natural reparative forces. Where a disturbance of the pressure balance within the tissues is complicated by an infection there is no chemical or emollient that has the antiseptic value of properly applied mechanical pressure as illustrated by the efficiency of complete circular stripping of the legs for a varicose ulcer or the application of a firm pressure dressing to any granulating surface. A pos

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sible reflection of this he feels is seen in those cases where skin grafts are applied with uniformly good takes in extremely contaminated areas such as the floor of the mouth. Here the graft is applied over a wax form which permits the reception of pressure sufficient to insure intimate and firm contact between the graft and the raw surface of the defect.

Blair listed four *advantages* from the application of a pressure dressing: (1) elimination of dead space, (2) the control of oozing, (3) the limitation of venous and lymph stasis and (4) the elimination of the amount of plastic material that pours into the wound. Another important advantage of the pressure dressing is the splinting effect which it lends to the soft tissues involved, keeping the part immobile and at complete rest. This factor serves to aid in wound healing and to protect the surgically clean wound against potential contamination for a long period with the elimination of much intense pain.

Numerous writers have emphasized the importance of pressure dressings in routine surgical cases. Royster² aware of their value following abdominal surgery, described a special type of pressure bandage which he employed. Pfeiffer³ and Dowling⁴ observed its value in surgical procedures about the eye. Other surgeons have encouraged the use of pressure dressings following surgical intervention at various anatomic sites.

Among enthusiastic advocates of pressure dressings in the treatment of burns have been Allen and Koch⁵ and Siler and Reid.⁶ The former described an important physiologic principle involved in the use of an adequate pressure dressing in the treatment of burns.

The elimination of dead space into which constant oozing can take place and the limitation of exudation from the surface of a wound *and into the subcutaneous tissues* are important objectives in wound treatment which are too often completely ignored. The surgeon who sees blood escaping rapidly from an open wound instinctively applies pressure to stop the bleeding and conserve vital body fluid. By some curious inconsistency, if we *cannot see it* we may ignore the subcutaneous bleeding that goes on just as definitely after the subcutaneous rupture of blood vessels and continues until it is arrested either by coagulation or by actual compression of the injured blood vessels by the tensed body tissues.

If the subcutaneous bleeding is the white hemorrhage that goes on in tissues injured by a flame or scalding water it needs to be arrested just as promptly as if the blood were escaping from a torn blood vessel. It can be arrested and body fluid saved by the application of pressure over the injured area.

The use of a properly applied pressure dressing in the treatment of burns or infected wounds lends itself to the application of an ideal method of treating these conditions since it incorporates basic fundamentals which insure the application of physiologic principles. I agree with Allen and Koch³ that a burn is primarily an open contaminated wound and logically should be treated as such. Of course, before the burn itself is treated shock if present or threatened must be combated.

If it is assumed that a burn is an open contaminated wound local treatment should consist first in conversion of the open contaminated wound into a surgically clean one and second in the application of a dressing which adequately protects the wound, directs counterpressure to the underlying tissues and establishes satisfactory drainage from the wound into the body of the dressing.

I thoroughly agree with the conclusions of Allen and Koch³ and Siler and Reid⁴ among others that one of the most effective methods for converting a contaminated wound into a surgically clean one is to be found in adequate cleansing by means of warm water and suds from a neutral white soap and large squares of moist sterile cotton. When it is realized that the ophthalmologist routinely cleans the surface of the cornea by gently rubbing or contacting its surface with pledgets of moist sterile absorbent cotton without injuring the cornea it can easily be understood that a contaminated surface may be cleaned with minimal trauma if this material is used.

Following thorough cleansing for a period of ten to fifteen minutes preferably ten minutes all remnants of blebs should be removed by sharp dissection and the area rinsed with saline solution. This completes the conversion of an open contaminated wound into a surgically clean one.

An effective means of converting the now surgically clean open wound into a closed one is accomplished by the proper application of a pressure dressing. Blair² has emphasized this

and Allen and Koch⁵ showed the importance of these dressings in combating white bleeding. Moreover it has been observed clinically that wounds to which pressure dressings have not been applied are extremely edematous whereas there is an absence of edema in those instances in which adequate pressure has been applied. This is particularly true in injuries to or about eyelids. The red firm granulation tissue over the surface of a wound to which adequate pressure has been applied may be contrasted with the pale edematous granulation tissue with considerable exudate seen in those cases treated without pressure. The deep and thickened keloid like scars developing from treatment without pressure obviously are the result of unsatisfactory healing. Owens and Patterson⁸ have shown experimentally the beneficial results which follow the application of pressure dressings to large burned areas in combating shock. They have demonstrated that immediate application of pressure to these open wounds forces the tissue fluids reflecting the outpouring of 'white bleeding' back into the vascular bed.

TREATMENT OF BURNS

As soon as a burned patient is received immediate attention is directed toward determining the presence or absence of shock. If shock is present or seems imminent prompt antishock measures are instituted until a safe physiologic balance has been established. Local treatment of the burn is administered as soon as possible. This consists in the following technic. Extreme care is taken at all times to protect the patient against all potential contamination arising from contact with external objects unnecessary contact with dust contaminated wards and above all contamination from the medical personnel through the hands or the unmasked nose or mouth. Hare⁹ has conclusively demonstrated the importance of avoiding these common sources of contamination and has shown that too often the medical profession is the chief offender in contaminating burned patients. The same protection should be afforded this patient that would be given any patient who is to have a major operation. All of the personnel should be properly gowned, sterile gloves should be used and masks of sufficient thickness to insure minimal contamination worn over the mouth and nose. All unnecessary

traffic in the operating room should be prohibited and a minimum of attendance permitted. Doors should be opened only when actually necessary. The temperature of the room should be kept at approximately 80° F. in contrast to the 100° F. which was commonly accepted a few years ago.

The patient should be given sufficient morphine (usually 1/4 grain) for analgesia. Preparation should then be begun for rendering the open contaminated wound an open surgically clean one. All clothing should be removed with the least possible amount of contamination or trauma to the patient, the clothes being cut off with sharp scissors if necessary. The patient should then be placed on sterile sheets. All burned areas should be gently washed with large pads of sterile absorbent cotton dipped in thick suds made with sterile water and a neutral white soap. The process is in no sense one which requires scrubbing; on the contrary, it should be carried out gently by slow rotary motion. This cleansing usually should be continued for a period of from ten to twenty minutes. The shorter time is probably more desirable since it is the opinion of many that cleansing for more than ten minutes might be sufficient to force organisms into the deeper skin elements, thus producing infection of the deeper layers which might otherwise have been avoided.

After the area has been thoroughly cleansed, the surgical personnel as well as the patient should be redraped in preparation for the final cleansing. All vesicles which have persisted during the initial cleansing should be opened and drained. All loose skin and remaining pedicles from vesicles should be removed by sharp dissection and the surface of the burned area should be gently rinsed with warm normal saline solution. By this time the contaminated wound, provided the surgeon has adequately cleansed the burned surface, should have been converted into a surgically clean wound. The burn is then ready for the reception of a pressure dressing designed to close the open wound.

APPLICATION OF THE PRESSURE DRESSING

Uninfected Burns

The first step in the application of the pressure dressing is to cover the entire burned surface with one single layer of fine

mesh (44 by 40) gauze (Fig 390 A) This gauze should be moistened with normal saline solution only because I believe that the application of any greasy substance to this dressing will interfere with drainage Over this one layer of fine mesh saline moistened gauze should be placed a layer of coarse mesh dry gauze about $\frac{1}{2}$ to $\frac{3}{4}$ inch in thickness (Fig 390 B) in order to give body to the dressing These two layers then should be wrapped snugly as a preparation for the application of adequate pressure Following this a layer of sterile fluffed mechanics waste about 6 inches in thickness (Fig 390 C) should be placed around the entire area to be enclosed in the dressing whether it be completely around the trunk the arm or the leg This should then be firmly fixed by a roll of bandage varying from 3 to 6 inches in width (Fig 390 D) depending on the size of the dressing and the anatomical location Firm pressure should be applied over the mechanics waste so that when the application has been complete the thickness of this layer of waste will have been reduced from approximately 6 to $3\frac{1}{2}$ inches Due to the fluffiness of this material extreme pressure may be applied since the waste acts as an excellent buffer for the even and equal distribution of pressure to the underlying tissues When extreme pressure is applied over a dressing the bandage should never be reversed since the point of reversal is prone to develop into a small cord which may constrict the underlying tissue Following the application of firm pressure one layer of water proof cellophane of sufficient size to permit an overlap of the pressure dressing at either end should be applied over the entire dressing (Fig 390 E) This should be snugly fixed with a roll of bandage and followed by the application of a final layer of 3 inch adhesive strips (Fig 390 F) Additional pressure is supplied by means of this final layer of adhesive

The patient should then be placed in bed over sterile sheets where he remains for eighteen to twenty one days before the dressing is changed During this period the patient is surprisingly comfortable The freedom from pain during the first eighteen to twenty one days is extremely important Perhaps in some borderline cases it means the difference between life and death Obvious beneficial effects from the prolonged application of the first dressing are time saved for those attending the patient



Fig 390

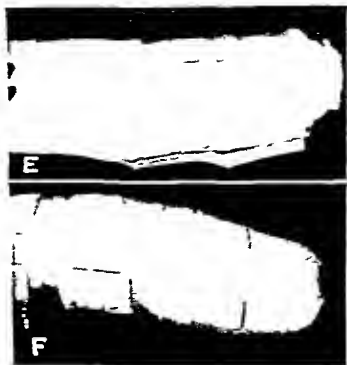




Fig 390

ected during this maximum period. An earlier change of dressing would reveal a healed wound in the first group or an incompletely separated slough if complete skin loss had been encountered. Nothing would be gained by an early change of dressing except to establish these facts. To change the dressing at an earlier date would subject those patients with a complete skin loss to one unnecessary exposure. When the first dressing is removed at eighteen to twenty one days it is our usual experience that the surgeon can apply skin grafts in a large number of those cases with complete skin loss. Subsequent dressings should be applied in the operating room. Every precaution to protect the patient against outside contamination must be observed at each change of dressing.

Infected Burns

In cases of infected burns the identical technic already described should be followed with certain additions. A formed dressing should be applied which is designed to incorporate varying numbers of Dakin's tubes between the layers of the gauze forming the dressing. This dressing should be tailored in a manner which permits it to be made as a single unit holding the incorporated Dakin's tubes fixed in their proper places between the layers of gauze by a basting stitch of cotton thread. The ends of the Dakin's tubes which extend beyond the margin of the dressing should be connected to a glass tube with multiple outlets. The large open end of this glass unit should then be connected to a rubber tube which is attached to an infusion bottle. A closed system for irrigation similar to that used in administering saline infusions or transfusions is thus established.

On the patient's return to the ward sterile normal saline solution or 2 per cent boric acid solution should be run from the bottle held above the level of the patient through the connecting tube into the incorporated dressing. This can be done by releasing a clamp which is applied to the main rubber connecting tube. A sufficient amount of the solution should be permitted to flow from the bottle into the dressing to give the patient a sensation of moisture. This procedure usually requires the instillation of 25 to 50 cc. of solution into the large dressings three to four times daily. During extremely hot weather instillations should be reduced to once every twenty four hours in order to diminish

the possibility of wound maceration. Excessive moisture along with moderate maceration seems to enhance rather than hinder the growth of *Bacillus pyocyaneus*.

By means of this technic one can establish sufficient moisture in the composite dressing to convert it into a capillary unit establishing drainage from the wound up into the substance of the dressing itself. These dressings should be changed every two to three days and at each change the patient should be adequately protected against potential contamination. While dressings are being changed the wounds may be gently cleansed with pledgets of moist cotton and soapsuds. Capillary pressure dressings apparently permit more rapid conversion of an infected wound into a clinically clean one and the application of pressure over the dressing helps to reduce the infection and to keep the granulation surface firm, flat and free of edema. This pressure also aids in minimizing associated scarring which frequently results if pressure has not been applied.

RATIONALE OF THE USE OF THE PRESSURE DRESSING IN BURNS

In surgically clean or in infected wounds the advantage of using one layer of fine mesh gauze moistened with saline solution is threefold: it minimizes the penetration of capillary buds into the substance of the dressing; it permits removal when moistened with normal saline solution with a minimum amount of pain and bleeding; and it permits constant drainage. I have found that grease dressings interfere with adequate drainage although some surgeons believe that this type of dressing facilitates drainage. If wounds are free of infection and completely healed it is not at all uncommon to find a layer of fine mesh gauze entirely dry and adherent to the surface of the wound (Fig. 393). In infected wounds treated with capillary dressings this layer of gauze is usually moist and adequate drainage occurs.

The addition of the outer layer of cellophane around the entire pressure dressing serves a definite purpose. The writer¹ has shown experimentally that outside contamination can reach a wound through the entire thickness of a dressing. In a group of experiments simulating moist dressing it was possible to draw organisms through as many as sixty-four thicknesses of gauze from the outside to contaminate the wound. In the second ex-



Fig 393—Appearance of the initial layer of fine mesh gauze at the first change of dressing. Complete healing has occurred. Note the firm adherence of the dressing to the dorsum of the hand and all fingers as well as the dry appearance of this fine mesh gauze.



Fig 394—Pressure dressing which has been applied to the penis. This photograph is shown to demonstrate the fallacy in the statement that pressure dressings cannot be placed around the genitalia or perineum. The application of this type of dressing is not uncommon and the patient experienced no discomfort from the applied pressure.

perimental group with the same technic except for the addition of one layer of waterproof cellophane between the dressings and the contaminant it was found that the contaminant failed to get through in practically every instance. This demonstrates the importance of interspersing a mechanical barrier designed to protect the wound against outside invasion through the dressing itself. This is the basis for the use of the cellophane wrapper.

SUMMARY

It has been our experience that by the use of pressure dressings in the treatment of burns and infected wounds the incidence of complications due to infection has been lowered the duration of hospitalization shortened and the complications reduced. A properly applied pressure dressing offers comfort to the patient during the first eighteen to twenty one days because of evenly distributed pressure and its splinting effect. This is in favorable contrast to those patients in that group who presented initially only contaminated wounds who formerly were subjected to the terrific pain associated with the frequent change of dressings during this period. The method of applying a pressure dressing is described in detail.

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SUBCAPSULAR ORCHIDECTOMY IN ADVANCED PROSTATIC CARCINOMA*

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W E. KITTREDGE MD‡

FROM the standpoint of treatment, prostatic carcinoma should be divided into early and advanced cases. The early cases comprise that group of less than 5 per cent of the total in which there is a small lump of malignant cells which has not yet broken through the prostatic capsule and spread into the surrounding structures. The only known cure for cancer of the prostate is radical perineal prostatectomy applicable only to those cases in which the diagnosis is made early enough to accomplish complete surgical removal of the diseased tissue. This small group of cases does not enter into the purpose of this discussion and therefore will not be further considered. The remaining group of 95 per cent or more of cases in which the disease has spread beyond the limits of surgery are advanced and incurable. For these cases the treatment should be directed toward symptomatic relief and what Bumpus¹ has termed the postponement of death by whatever methods are indicated in the individual case.

EVALUATION OF METHODS OF SYMPTOMATIC TREATMENT OF ADVANCED CANCER OF THE PROSTATE

The outstanding symptoms caused by advanced cancer of the prostate are those resulting from obstruction at the bladder neck and pain from metastasis. The pain is produced by pressure

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perimental group with the same technic except for the addition of one layer of waterproof cellophane between the dressings and the contaminant it was found that the contaminant failed to get through in practically every instance. This demonstrates the importance of interspersing a mechanical barrier designed to protect the wound against outside invasion through the dressing itself. This is the basis for the use of the cellophane wrapper.

SUMMARY

It has been our experience that by the use of pressure dressings in the treatment of burns and infected wounds the incidence of complications due to infection has been lowered, the duration of hospitalization shortened and the complications reduced. A properly applied pressure dressing offers comfort to the patient during the first eighteen to twenty one days because of evenly distributed pressure and its splinting effect. This is in favorable contrast to those patients in that group who presented initially only contaminated wounds who formerly were subjected to the terrific pain associated with the frequent change of dressings during this period. The method of applying a pressure dressing is described in detail.

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forty three days after operation, the diagnosis of carcinoma of the prostate was not confirmed at autopsy. Three patients died eight months, seventeen months and three and a half years after operation. The other patient still living at the end of six and a half years had metastases to the dorsolumbar spine. These cases were presented for the facts that they carried and not as an argument against the trend of present day therapy. In none of the cases was a cure effected.

Munger⁴ in 1941 reported the results in eleven patients with prostatic carcinoma treated by transurethral resection and planned irradiation of the testes. Eight of the eleven patients were living, five of whom had been examined within a year of the time the report was published. The longest time of survival was seven years and the shortest three years. He stated that rectal examination in almost every case presented minimal findings that would lead one to diagnose cancer of the prostate. He thought that the metastatic areas seemed to become stabilized and that these patients did not experience as much trouble symptomatically as those in the group which did not have testicular irradiation.

A careful review of the literature indicates that one is rarely if ever justified in attacking the primary growth either with radium or x-ray. The reactions are often severe and Hinman⁵ states that no case has ever been cured by either method.

Relief from pain in cancer of the prostate has been reported from the use of drugs, section of nerve roots and the pain pathways of the spinal cord, deep x-ray therapy to the metastatic areas and intraspinal injections of absolute alcohol. These methods have been used long enough to justify accurate evaluation of results.

Dean and his associates⁶ for a number of years have measured the acid and alkaline serum phosphatases in patients suspected of having prostatic cancer. They feel that these are not only accurate diagnostic tests but also may be used as an index in measuring the response to treatment.

Huggins and his co-workers⁷ studying the serum acid phosphatase in cases of known carcinoma of the prostate found it to be greatly increased in most cases with widespread metastases. They also observed that the activity of the neoplasm could be increased by the injection of an androgen and greatly decreased

There is little postoperative reaction and these patients are usually able to leave the hospital within forty eight to seventy

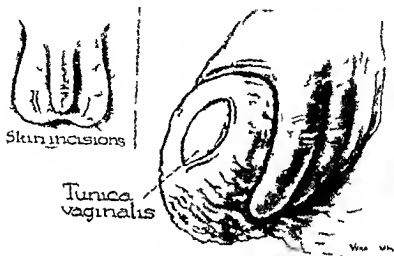


Fig 395—Bilateral scrotal incision Testis presented in vulva and tunica vaginalis incised



Fig 396—Tunica vaginalis opened Testicular tissue exposed and capsule everted

two hours The rubber wick is removed from each side of the scrotum before the patient is discharged Within several weeks

of the operation all edema and inflammation subside and, on palpation a mass about the size of the end of the thumb is found to remain in each side of the scrotum

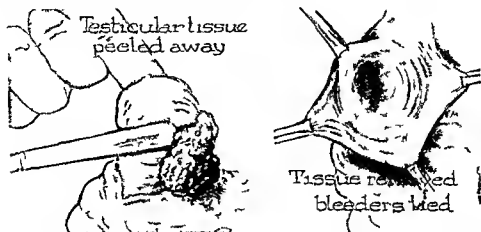


Fig 397—Testicular tissue peeled away and all bleeding points tied leaving clean dry surface

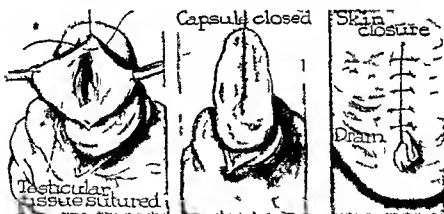


Fig 398—Tunica brought back together by continuous catgut suture with out drainage Lower scrotum drained by rubber dam Skin closed with plain No 0 catgut sutures

RESULTS OF THE OPERATION

In conversation with these patients afterwards it will invariably be noted that they are totally unaware of the fact that any tissue has been removed. There were no operative deaths in our series of twenty three cases.

In this group of twenty three patients operated on in the last eight months a reduction in the size of the primary growth

after the testicles were removed was noted in seven. These patients had had a prostatic resection shortly before orchidectomy a factor which we believe contributes to reduction in the size of the mass in the majority of cases. In one case with partial urinary obstruction the testicles were removed without any treatment of the prostate. Thus far (at the end of three months) the patient has had neither reduction in the primary growth nor improvement in urinary function. Twelve patients were completely relieved of pain the relief usually being felt within the first two or three days. One man who had been taking three or four doses of morphine a day for a period of weeks experienced considerable relief from pain within forty eight hours and at the end of ten days was able to leave the hospital and required only an occasional dose of codeine. Pain recurred however at the end of eight weeks and was just as severe as before the testicles were removed. He had received stilbestrol prior to orchidectomy without relief and got no benefit from its administration after the recurrence of pain. He died from widespread metastases four months after the testicles were removed. One patient who had considerable pain on admission experienced no change in his symptoms after the testicles were removed. Seven patients had no pain other than the discomfort associated with urinary obstruction which was relieved by prostatic resection. Follow up reports could not be obtained from the remaining three cases.

One patient in whom there was evidence of early metastatic lesions in the pelvis and lumbar spine in October 1941 when the testicles were removed showed x ray manifestations of considerable extension of the process by January 1943. Repeat x rays in March 1943 showed no further extension of the metastatic lesions and at least temporarily the metastatic lesions were apparently stabilized. A second patient who had had a prostatic resection six years ago for Grade I adenocarcinoma and who had widespread metastatic lesions in the pelvis and lumbar spine obtained relief from pain from the administration of stilbestrol prior to orchidectomy. Since the removal of the testicles six months ago there has been no further extension of the metastatic lesions and at the present time he remains free from pain. In a third case with metastatic nodules in the glands of the neck and groin the size of these nodes were greatly re-

duced at the end of three weeks. This is the only case in which there has been regression of the metastatic lesions. In all other cases with demonstrable metastatic lesions there has been a progression of the metastatic process. Two patients had edema of the legs and both were completely relieved after prostatic resection and orchidectomy.

All patients who obtained relief from pain likewise showed much improvement in general health. There was an average gain in weight of 9 pounds and an improvement in the red blood cell and hemoglobin values. Whether or not this can be attributed to removal of the testicles or to relief from urinary obstruction cannot be determined at the present time, but we are inclined to give considerable credit to the relief from urinary obstruction. We have found that urinary infection cleared up in those cases in which there was complete relief from urinary obstruction but did not if the obstruction was not completely relieved.

Undesirable results include complete loss in sexual power in all cases and hot flashes in a few. The hot flashes may sometimes be relieved by the administration of stilbesterol.

SUMMARY

The rationale of orchidectomy in the treatment of carcinoma of the prostate is discussed. The results of a series of twenty-three cases of subcapsular orchidectomy are reported. The technique of subcapsular orchidectomy is described.

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THE TREATMENT OF TRAUMATIC ARTERIOVENOUS ANEURYSMS (ARTERIOVENOUS FISTULAS)

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THE complex effects of arteriovenous aneurysms make it particularly necessary for the surgeon to be familiar with the physiopathology of this condition. Not only are profound disturbances often produced in the cardiovascular system but owing to the exigencies of the situation compromises must sometimes be made during a local surgical procedure. For this reason a knowledge of the mechanism which produces the disturbed physiologic condition is essential to secure the best results with minimal risk to the patient.

PHYSIOPATHOLOGY

Traumatic communications between veins and arteries are usually produced by penetrating wounds which injure both vessels as they lie side by side but there is at least one common type which results from indirect trauma. This is the carotid cavernous sinus fistula resulting from a fractured skull and made possible because of the peculiar anatomy of this region. This is the only place in the body where an artery is surrounded by a vein and although the exact means of wounding is sometimes doubtful it is easy to understand why injuries in this region damage both channels. It is sometimes difficult to exclude previous trauma as the cause in these instances a congenital origin must be considered. Patey¹ reported an interesting case of a nine year old girl who sustained a fall which caused no external bleeding but left a firm mass in the scalp. An arteriovenous aneurysm developed at this point at the age of forty two years. However in the intervening years she had been treated with

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electric needles after which there was some hemorrhage. In this instance the fistulous communication probably arose from the puncture wounds and not from the previous blow although the possibility of a congenital origin cannot be eliminated.

Because there is a shunting of the arterial blood into the vein when fistulas occur less blood reaches the artery distal to the

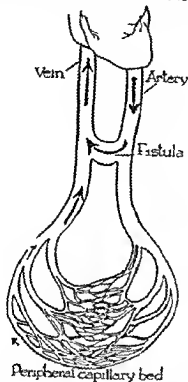


Fig. 399—Mechanism by which blood is shunted from arterial to venous trunks thus depriving the distal artery and the peripheral capillary bed of their normal blood supply. Note that the amount of blood transferred to the veins will depend on the size of the fistula and the size of the vessels involved. The abnormal direction of the flow is brought about by peripheral resistance on the arterial side and low pressure on the venous side.

injury (Fig. 399). A part of the blood volume therefore fails to reach a peripheral capillary bed but is aimlessly shunted back through the lungs and heart. When this happens suddenly the blood pressure falls and the cardiac rate increases the latter is undoubtedly a compensatory phenomenon. Holman has shown that other adjustments are made which serve the same purpose for he has demonstrated an increased blood volume as well as an

increased minute volume output of the heart. As compensation takes place blood pressure rises and pulse rate decreases. The severity of these acute circulatory disturbances depends on the size of the fistula and its proximity to the heart. Large fistulas in the great vessels sometimes produce such profound changes that death promptly ensues or there are evidences of an attempted adjustment persisting for weeks. As soon as the enlarged blood volume and the increased cardiac output satisfy the circulatory demands the pulse rate and blood pressure return to or approach normal. During this process of compensation the heart becomes dilated and hypertrophied principally the former, but the increased burden sometimes brings about cardiac decompensation after a variable time has elapsed. If there is a small opening far from the heart usually only local effects will be manifested but if the amount of blood shunted from one system to the other is large more widespread circulatory alterations are uniformly found.

There is much evidence to indicate that sudden closure of a fistula has the opposite effect to that caused by its sudden production. Thus blood pressure is elevated the pulse rate is reduced and the blood volume then being relatively great begins to diminish. In addition cardiac dilatation decreases. Most of these changes occur fairly rapidly but it should be remembered that neither the action of the heart nor the blood volume can immediately return to normal. Until this occurs a weakened heart must handle an increased blood volume the added burden on an already handicapped heart may then produce decompensation. The significance of this in treatment is too often disregarded. Local effects of fistulas should also be considered in selecting the type of treatment. Enlargement of the proximal artery and vein which regularly takes place often complicates the operation. It should always be remembered that there is an increase in the neighboring collaterals and every effort should be made to preserve these if treatment requires the interruption of a main artery. All of these changes are dependent on the volume of blood passing through the abnormal communication for in small openings there is little dilatation of the proximal vessels and little need for collaterals. Likewise if unimportant vascular trunks are involved their removal will not endanger the nutrition of the part.

GENERAL CONSIDERATIONS

Successful surgery of aneurysms of the large vessels requires a thorough knowledge of fundamental principles and special technics. It is essential to be familiar with tests to determine the adequacy of the collateral circulation before the involved vessels are permanently obliterated because much can be done to improve this condition preoperatively. Efficient tourniquets, small needles and the proper suture material are important parts of the armamentarium. Rigid asepsis is the keystone to success but this may be vitiated by rough handling of tissues which predisposes to infection. Picks and drains are invitations to disaster and should always be avoided unless contamination or infection makes such a course unwise. In vascular surgery primary healing is one of the sure roads to success.

If gangrene is imminent the surgeon must decide upon the best position for the part. It is impossible to make the decision categorically. One of the most important advances in the treatment of vascular disease has been the realization that there is a position of maximum circulatory efficiency which varies with each patient. However this is generally found to be several centimeters below the level of the heart. The patient should be kept in that position which provides the best circulation as determined by the patient's reaction and the objective findings in the part.

It is even more difficult to determine whether or not heat should be applied. Wrapping the extremity in cotton is a time honored custom. However Allen³ has demonstrated experimentally the advantage of refrigeration. Despite this confusion there are several established facts which form the basis for treatment. It is well known that the best way to cause vasodilatation is to put the patient in a warm room. On the other hand cold produces spasm. Low temperatures diminish tissue metabolism thus lowering the oxygen requirement. Heat produces vasodilatation and an increased local metabolism whereas cold has opposite effects. The therapeutic application of heat or cold would seem to lie in selecting the desired action of each. In the presence of mild ischemia a light cotton wrapping for the extremity will prove sufficient but if there is a definite threat of gangrene sympathetic block is indicated. Refrigeration should never be used unless there is a severe grade of ischemia and then only

after the sympathetics have been interrupted either by excision or by chemical block.

EMERGENCY TREATMENT

Early Diagnosis—Arteriovenous fistulas can be recognized or at least suspected early after their inception. The importance of early diagnosis lies in avoiding ill advised improper therapy which at this time can lead to the loss of an extremity infection or fatal hemorrhage. The presence of a penetrating wound a hematoma and a thrill should always suggest an injury to both artery and vein. Pulsation is variable and the thrill sometimes fails to develop for several days although usually it is manifest within a few hours. Such patients are treated for shock after which attention is directed toward the superficial wound.

Care of the Superficial Wound—After a wide area of surrounding skin has been cleaned and painted with a germicidal solution sulfathiazole gauze and an adequate dressing should be applied. Frequent changes of dressings should be discouraged. A sulfonamide preferably sulfadiazine is given orally or intravenously. No other local treatment except immobilization is necessary until the patient is in an adequately equipped hospital unless a tourniquet is required to control external bleeding in which case early ligation is usually essential. Whenever possible the patient should be watched and treatment deferred although superficial debridement of the surface wound might be permitted.

Treatment of Complications

In many instances this early period is beset with trying complications. The three conditions that are most likely to disturb more deliberate treatment are hemorrhage infection and threatened ischemic gangrene. These complications demand prompt active measures.

Hemorrhage—Significant external hemorrhage may occur immediately or as a later complication the latter being usually associated with infection. Regardless of the mechanism bleeding must be controlled either temporarily by means of a tourniquet or by ligation of the involved vessels. When indicated operation is done with the use of a tourniquet and the injured segment of artery removed between ligatures. The vein should

also be ligated proximal to the opening but excision is not necessary. By such a procedure the surgeon avoids the well known disadvantages of ligating the artery in continuity and also minimizes the chances for occurrence of an embolism from the vein. The wound may be debrided at the same time but due regard must be given neighboring collateral vessels for frequently their patency is the determining factor in preserving adequate circulation to the part. The wound is then closed without drainage.

Infection—Large grossly contaminated wounds are treated by the usual methods of cleansing, debridement and chemotherapy and in most instances it will be necessary to ligate vessels at the same time. In the presence of established infection secondary hemorrhage is likely and decisive steps should be taken promptly for its control. The actual occurrence of hemorrhage from an infected wound demands immediate surgical intervention. With a tourniquet in place the area is widely incised, the clot evacuated and a limited debridement done. The injured vessels are then ligated as previously described and the wound is left open. After removal of the arteriovenous fistula conventional treatment of the infection can be instituted. Irrigation is particularly beneficial but Dakin's solution should not be used because at times it causes secondary hemorrhage from the ligated vessels. The same danger is inherent in other agents which have a pronounced liquefying action on devitalized tissue.

Threatened Ischemic Gangrene—Early ischemia is obviously a serious complication for gangrene is not uncommon when the main vessels in the extremities are injured. Several factors may operate to bring this about. In the first place the injury may be followed by a distal thrombosis in the artery but even if this does not occur shunting of arterial blood into the veins deprives the more remote tissues of their normal supply. Then too such injuries are always accompanied by edema and the formation of hematomas. The hematomas cause pressure on the surrounding structures and the edema is responsible for shutting off important vessels in the region. In addition a widespread vascular spasm initiated and maintained by the vascular lesion often plays a prominent role. Another factor not sufficiently recognized in the past is the effect of general circulatory disturb

ances such as shock or lowered blood pressure from any cause this can exert a profound influence on nutrition in the area already affected by the lesion. The total effect will be evident although it is not always easy to evaluate the different components. If evidences of serious ischemia are accompanied by an enlarging hematoma the latter should be evacuated and the vessels ligated. The severity of vascular spasm can be determined by sympathetic block with procaine hydrochloride and when present to a significant degree it can be controlled by repeated blocks every forty eight hours. This should be done in all cases in which block offers a possibility of avoiding early operation or preventing gangrene. Therapy directed toward maintaining an efficient general circulation is of course mandatory.

ELECTIVE TREATMENT

Many patients weather this early period without serious complications and after the acute phase suffer only from the effects of the fistula. The external wounds have healed, the hematoma has been absorbed and the threat of ischemia has been at least temporarily overcome. Reid and Andrus⁴ have rightly advocated *delay in operating* whenever possible, pointing out that this allows the formation of collateral circulation and permits the tissues to approach normal, thus facilitating dissection. From six weeks to six months should therefore elapse between injury and operation unless compelling circumstances dictate otherwise. Many patients tolerate the residual condition well enough; consequently the wisdom of operation at this stage is sometimes questioned.

I believe that almost all patients should be operated on. In addition to the size and location of the fistula its *duration* is a factor of equal importance in producing late manifestations. The ill effects are a product of the amount of blood flowing through the fistula multiplied by its duration. There is evidence that the local dilatation of the proximal vessels tends to increase with the passage of time until further enlargement has been restricted by the surrounding structures. Then too the demand on the heart is greater than normal and if great enough will finally bring about decompensation. For this reason a patient may be in excellent health two months after injury and in cardiac decompensation a year later. All large fistulas there

fore should be eliminated whenever possible. If smaller vessels are involved operation is advisable because of its simplicity and safety particularly if local changes might develop later.

Preoperative treatment in these elective cases is directed toward preventing two possible postoperative sequelae ischemia of the part and cardiac decompensation. In small communications located in unimportant vessels neither of these is likely and no special preoperative treatment is necessary.

Inasmuch as operative treatment will in most instances interrupt the artery, the effects of this should be anticipated. Occlusion of the artery at the fistula by digital pressure or by mechanical means will test the adequacy of collateral circulation. This of course cannot be accomplished by a circular con-

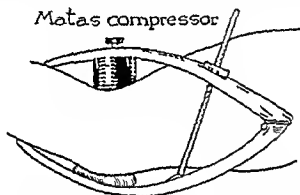


Fig. 400.—The Matas compressor occludes the popliteal vessels.

strictor because then the collaterals will also be shut off. It is necessary to maintain pressure long enough to make the result evident in the tissues situated distally. This is particularly important when ligation of the carotids is contemplated. In this instance temporary occlusion will be followed by syncope if collateral circulation is not adequate. Under these circumstances steps should be taken to improve the condition before operation is attempted. The simplest method is to allow more time to elapse because the presence of the fistula is itself a powerful stimulus. In addition active measures often prove valuable. Obliteration of the artery at the fistula by digital pressure for fifteen or twenty minutes several times a day is of proved value. A Matas compressor (Fig. 400) also serves well for this purpose. Gage and Ochsner³ suggested sympathetic block or

even sympathectomy to dilate the smaller vessels and in this way facilitate their development. This certainly should be utilized in all cases in which ligation will prove hazardous. Reflex dilatation with heat is beneficial, this is accomplished by applying heat to some other part of the body such as the chest, abdomen, or an uninvolved extremity, but the best plan is to keep the patient in a warm room. Conversely, chilling or cold is to be avoided.

In the discussion of the cardiac changes accompanying arteriovenous fistulas, it was shown that these will depend on the size of the opening, its position in the vascular tree, and its duration. Small peripherally situated lesions will usually cause no demonstrable effects, and if this is true, there should be no reason for special concern before operation. The extent of damage to the heart can be judged by the degree of dilatation as measured on x-ray films and by functional tests to estimate cardiac reserve. Electrocardiographic studies are also useful. It should be emphasized that a good deal can be done to improve the heart and the general circulatory efficiency before operation. Most surgeons agree that frequent obliteration of the fistula with digital compression (or mechanical means such as the Matas compressor) is definitely worthwhile. However, the greatest benefit in this respect will be derived from complete bed rest for ten days or more, the time being determined by continued progress of the patient. It is wise to insist on bed rest until no further progress is evident. Digitalis is of doubtful value under these circumstances.

Elective Operations

Preservation of Vessels—It is sometimes possible to obliterate the fistula while preserving the integrity of the vessels. This entails suture or ligation of the openings. It is always desirable to divide or excise the fistulous tract. Nonabsorbable suture material should be used, and if the opening is sutured, extremely small needles carrying especially fine silk are necessary. Many authors suggest that the stitches include all coats of the vessel except the intima, although some prefer a cobbler's stitch through all coats, producing an eversion of the edges. It is much more important to maintain arterial channels than it is to save the veins; in fact, the vein should never be reconstructed after

ligation of the artery. Hemostasis and asepsis should be perfect when this method is used. Rarely the communication is small and can be ligated. Mattis⁶ suggested applying the principle of endo aneurysmorrhaphy if the sac is large. To accomplish this the sac is widely incised while hemorrhage is controlled by a tourniquet or appropriate clamps on the artery and vein, the orifices of the vessels are thus exposed and may be closed. The sac is excised or obliterated. This procedure is not recommended unless the lumen of the artery is well preserved.

Such attempts to preserve a normal blood flow are often spoken of as the ideal or most desirable methods whenever applicable. However because they have serious disadvantages, the accuracy of the term ideal is questionable. In the first place few traumatic fistulas lend themselves to such procedures and furthermore conditions must be ideal in order to anticipate a good result. They should not be attempted except by experienced surgeons in well equipped hospitals. Contaminated wounds or a necessity for drainage are contraindications and the artery should never be sutured when it can be ligated without danger. The late results are not reassuring. Mitchiner⁷ contends from experience in the last war that thrombosis occurs in a large majority of these cases thus defeating the purpose of reconstruction. However thrombosis brings about a cure whereas aneurysms are prone to develop later in those patients in whom arterial flow has been preserved.

Complete Excision of the Fistula—The aneurysm will obviously be cured if the involved vessels are completely excised with their communication (Fig. 401). This is the preferred method in all cases except those in which the fistula is inaccessible or its dissection hazardous. In these cases the surgeon must compromise.

The thrill and pulsations provide valuable guides in the dissection yet a tourniquet is most essential at times. Whenever feasible it is a good plan to begin the operation with a tourniquet in place but not tightened, then it can be brought into use when necessary. The dissection is carried down to the vessels and the artery proximal to the fistula is isolated. A piece of heavy silk or braided cotton is passed beneath it and made ready for tying. If bleeding should occur it can usually be controlled temporarily by digital pressure until this ligature can be

pulled tightly. The artery is then followed downward along the side away from the vein to a point below the fistula and another ligature placed loosely around it. Dissection is then carried up the side of the vein away from the artery until ligatures can be placed on each side of the lesion. After all four poles have been tied off that segment of the vessel between these can be excised *en masse*, usually followed by little bleeding unless entering collaterals have been neglected. Significant hemorrhage most often occurs during the process of clearing the vessels readying them for ligation.

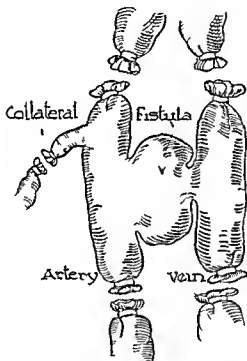


Fig. 401—Ligation of artery and vein both proximal and distal to aneurysm. The tissues thus isolated should be excised if considered prudent.

Quadruple Ligation without Excision—Quadruple ligation without excision (Fig. 402) is the procedure of second choice which is sometimes made necessary because of difficulties in dissecting out the aneurysm. The four ligatures are put in position and tied as already described but no tissue is excised. However, every effort should be made to divide the proximal artery in order to avoid ligation in continuity. One is sometimes tempted to leave the vein untouched but this is always to be avoided because the result is usually disastrous.

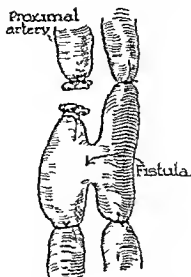


Fig. 40—Quadruple ligation without division. Note that the proximal artery has been divided to a distal ligation in continuity.

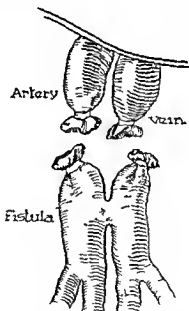


Fig. 403—Ligation of proximal artery and vein with division of both.

Ligation of Proximal Artery and Vein—Ligation of the proximal artery and vein (Fig. 403) is a distinct compromise which should never be performed unless a more radical pro-

cedure is impossible. It consists merely in tying off the two vessels proximal to the arteriovenous communication. Better results will be obtained if this is done as near the fistula as possible.

Ligation of Proximal and Distal Artery—There will be found little occasion to resort to ligation of the proximal and distal artery because ordinarily the vein can also be occluded (Fig 404). Danger of recurrence lies in the possibility of collaterals at the fistulous site reestablishing arterial communication with the veins.

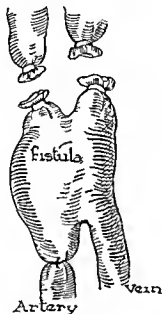


Fig 404—Ligation of proximal artery and vein accompanied by ligation in continuity of distal artery.

Contraindicated Procedures

Unsatisfactory results following obliteration of the proximal artery without similar treatment of the vein has already been mentioned (Fig 405). It is clear that this situation permits blood brought to the region by collaterals to be diverted into the veins, thus depriving the distal capillary bed of its supply. The patient literally bleeds into his veins, creating an ischemia in the more remote tissues. It is true that there are times when the accompanying vein is not occluded, but even then the results would be better if the opposite were done. An example is found in carotid ligation, for too often the internal jugular vein is left undisturbed.

Another contraindicated procedure is ligation of the proximal vein alone. It is probably safe to say that no large arteriovenous aneurysm has ever been cured by this method.

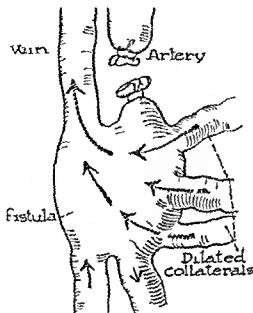


Fig. 403.—Schematic illustration to show undesirable effects produced by ligation of proximal artery alone. It will be seen that all blood entering the aneurysm from the collateral vessels tends to return to the heart through the patent vein and the arterial flow through the distal artery is greatly diminished. It is easily seen that this situation predisposes to distal ischemia.

CAROTID CAVERNOUS SINUS FISTULA

Carotid cavernous sinus fistula is difficult to treat because of at least two uncontrollable factors. This fistula cannot be attacked directly because of its position and the proximal vein cannot be obliterated near the lesion. To these should be added the direct effects of ischemia following interruption of the arterial flow. Treatment is generally confined to carotid ligation although other complementary measures have been tried.

It is most important to determine *in advance* what effects will follow carotid occlusion. In his classical report of 600 cases in which this was done, Pitz⁸ stated that cerebral symptoms developed in over 30 per cent of cases. The artery on the affected side should be occluded by digital pressure and the results observed. The sudden appearance of faintness or unconsciousness

is an indication that collateral circulation is insufficient but if mild symptoms intervene only after eight to ten minutes it is probable that ligation will be tolerated. If the collaterals are inadequate the patient should be instructed to compress the vessel several times a day each time maintaining the pressure until symptoms appear. Considerable improvement can usually be obtained in this way.

In my estimation the method of choice consists in ligation of the common carotid *first* in all cases in which there is any doubt as to how ligation of the internal artery would be tolerated. It has been estimated that occlusion of the common carotid reduces the flow through the internal branch about 50 per cent the explanation being the large back flow from the external carotid derived from rich anastomoses with its fellow on the opposite side. The internal carotid can be shut off later with much greater safety if required because collateral circulation has been developed under this stimulus. In addition to this type of proximal ligation attempts have been made to introduce sclerosing substances into the cavernous sinus through the orbital veins. These have not met with great success. Brooks⁹ introduced a small piece of muscle into the carotid artery and allowed the blood stream to carry it upward hoping to plug the opening in that way. The two patients on whom this method was used were cured.

The high incidence of cerebral symptoms following carotid ligation has encouraged the use of various methods designed to bring about a more gradual occlusion. *Aluminum bands* or strips of *fascia lata* are placed around the vessel tightly enough to constrict the lumen and thus reduce blood flow past that point. Because the metal has sufficient rigidity to overcome the propulsive force it is only necessary to mold it with the fingers around the vessel to the required smallness. *Fascia* is made into an encircling ring by fixing it with small nonabsorbable sutures. It is of course always desirable to constrict the artery to the greatest degree compatible with safety. Local anesthesia has the distinct advantage of allowing the immediate result of partial occlusion to become evident hence the band can be more exactly regulated. Under general anesthesia there is no such guide and the band is so placed that it greatly reduces pulsation in the distal artery. In such cases as the patient becomes conscious

he must be observed carefully for the earliest detectable symptoms indicating cerebral ischemia and should these be sufficient the band is removed immediately. When all goes well about one month or more should elapse before complete occlusion is accomplished at a second operation.

Although bands are at times beneficial I believe that they should be used only in those cases in which no other alternative is safe. I also strongly favor attacking the common carotid first. Often ligation here is less dangerous than partial occlusion of the internal artery and either method necessitates multiple stages. If preoperative studies indicate that interruption of the blood supply might be dangerous it is preferable to expose the common carotid under a local anesthetic and test the effects of temporary occlusion. If this is well tolerated ligation can be carried out. At the second operation the internal carotid can then be dealt with. Here again the advantages of testing the effects of occlusion on a conscious patient are obvious but the artery is difficult to expose under local anesthesia. The external carotid can be more easily exposed and its obliteration brings about the same result if the common carotid has already been ligated. It will be advisable occasionally to band the internal artery even though the common carotid has already been occluded. In my estimation this is the only time that bands should be used in this region.

SUMMARY

A thorough knowledge of the physiopathology of arteriovenous aneurysms and of special techniques in vascular surgery is essential for successful treatment of this condition. Emergency treatment consists in overcoming shock, locally treating the wound and adopting measures for controlling hemorrhage and combating infection and ischemia. Surgical intervention should be deferred for several weeks if possible.

In the elective operation preoperative treatment is directed toward preventing postoperative ischemia and cardiac decompensation. The most satisfactory operation for arteriovenous aneurysms is complete excision of the aneurysm and the involved vessels but this is not always feasible and other surgical measures must be substituted. Several of these are discussed. Ligation of the proximal artery without similar treatment of

the vein gives unsatisfactory results and ligation of the proximal vein alone should never be attempted

The best method for treating carotid cavernous sinus fistula is ligation of the common carotid first in all cases in which there is any doubt as to how ligation of the internal carotid will be tolerated. Later the internal carotid can be dealt with

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THE TECHNIC OF GASTRIC RESECTION FOR DUODENAL ULCER*

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THE indications for surgical treatment of duodenal ulcer form no part of this discussion. We must state however that surgical therapy has no place in the management of a patient suffering from an uncomplicated duodenal ulcer; that it is applicable only to those patients who suffer from the following complications of duodenal ulcer: acute perforation, recurring hemorrhage, penetration, pyloric stenosis or duodenal ulcer oculta; and that gastric resection should never be carried out until nutritional and biochemical disturbances have been corrected to the greatest possible degree.

Anesthesia

All the patients who come to the operating room for a gastric resection have a Levine tube in the stomach and the stomach is empty. We are now using routinely continuous spinal anesthesia as suggested by Lemmon.¹ We have overcome completely our original horror at the thought of a needle remaining in the spinal canal for two hours or more. We have had nothing but the most satisfactory results from this form of anesthesia which has abolished completely the hazards which had occurred previously when spinal anesthesia had to be supplemented or replaced by inhalation or other forms of anesthesia.

Exposure of the Abdomen

The upper abdomen is opened by a paramedian incision. If the patient is young, if there has been no immediate massive hemorrhage requiring multiple transfusions or a gross nutri-

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tional disturbance it is our practice to displace the upper right rectus muscle laterally before entering the peritoneal cavity through the posterior sheath. We have found it of inestimable value to carry the skin incision high enough up on the costal margin to displace the rectus laterally above its highest tendinous inscription. This maneuver greatly increases the efficiency of the exposure. In patients who have recently had a massive hemorrhage or who suffer from gross nutritional disturbance resulting from either a pyloric stenosis or from a prolonged inadequately balanced diet the abdomen is opened by splitting rather than displacing the right rectus muscle. In this latter group the wound is closed by means of figure of 8 stainless steel wire after the manner suggested by Jones whereas if the muscle be displaced the wound is closed by continuous catgut in the anterior and posterior sheath of the rectus supplemented by interrupted sutures of No. C silk. We have found no evidence to support the oft repeated statement that the use of silk and fine catgut in the same wound is contraindicated.

Survey of the Peritoneal Contents

After the peritoneal cavity is opened a general survey is made of the peritoneal contents. It is our practice first to examine and palpate the areas in which no pathological lesion is suspected reserving for a final survey the area which harbors the structural disease in this instance the duodenal cap.

It is extremely important that one carefully examine the descending duodenum. Unless this be done deliberately it is possible to miss what we have been pleased to call duodenal ulcer occulta. Such an ulcer lies on the posterior wall of the descending duodenum and because of its proximity to the common bile duct produces edema and subacute obstruction of the common bile duct with symptoms and on occasions jaundice which may mislead the physician and surgeon into considering that the primary lesion lies in the biliary apparatus. The site of the ulcer renders its demonstration difficult unless special x-ray technic is used.

Mobilization of the Liver

Having confirmed the presence of a duodenal ulcer we then divide the round ligament of the liver together with the perit-

oneal reflection of the falsiform ligament. This readily mobilizes the liver and permits easy exposure of the lesser curvature of the stomach.

Free Mobilization of the Duodenum

One of the greatest hazards of gastrectomy for duodenal ulcer is a leak from the duodenal stump. In our opinion this hazard can be reduced greatly by adequate mobilization of the duodenum. For this reason free mobilization of the duodenum becomes our first step in the operation. With abdominal packs controlling the intestines and with traction made on the descending duodenum downwards and medially it is possible to expose the peritoneal reflection on the convexity of the second part of the duodenum. This can be divided with practically no bleeding and permits one to roll the duodenum medially and visualize the vena cava. At the same time the dissection is carried towards the duodenal cap sufficiently far to expose and identify the relationship of the common bile duct to the duodenal lesion. It may be necessary to tie but one or two vessels. It is then an advantage to divide the peritoneal reflection on the concavity of the second part of the duodenum. This can be done usually without any bleeding. An abdominal pack then placed in this area will complete the hemostasis while one proceeds with the mobilization of the stomach.

The second step is to open the lesser sac below the greater curvature of the stomach and divide the anterior layer of the gastrocolic omentum between a series of haemostats. As this lesser sac is opened progressing in a direction towards the pylorus one encounters a reflection of the posterior layer of peritoneum of the lesser sac onto the posterior wall of the stomach. By using the principle of creating tissue tension by retraction of the posterior wall of the lesser sac downwards and medially and retraction of the pyloric end of the stomach upwards and laterally it is possible to create tissue tension at the site where the peritoneum is reflected onto the posterior wall of the pylorus. Sharp knife dissection along this line of reflection of peritoneum will readily mobilize the entire posterior wall of the pyloric antrum in a completely bloodless manner. This will enable the surgeon to carry the dissection down to the pancreaticoduodenal artery, which can be dissected free and isolated as a trunk. It

is our practice to triple clamp this artery, leaving two clamps on the proximal side and in this manner it may be secured by a double ligature. By inserting the fingers of the right hand underneath the pyloric antrum with the thumb over the pylorus it is possible to dissect the right gastric artery just distal to the pyloric sphincter. This vessel is isolated, triple clamped and doubly ligated.

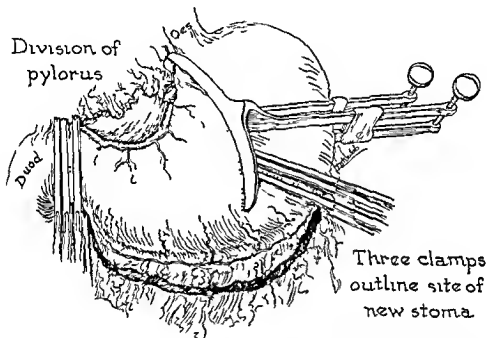


Fig 406—The application of three Kocher forceps leaving two on duodenal stump after division of pylorus permits the division of the duodenum so that the Schoemaker clamp may then be applied. It is important to determine the site of the greater curvature where the stomach should be divided and apply here three forceps, two of which will be left on the gastric stump after the division. The Schoemaker clamp is applied only after the pylorus is divided and enables removal of the entire lesser curve. The stomach is divided as indicated on the dotted line leaving an excess distal to the clamp on the lesser curvature so that it will not retract between the blades of the clamp.

At this stage therefore one has adequate mobilization of the greater curvature to a point where the proposed division of the stomach may be carried out and also a mobilization of the lesser curvature up to the entrance of the left gastric artery. The duodenum is then divided by means of the triple clamp method (Fig 406). The removal of the proximal of the two clamps remaining on the distal duodenal stump as shown in Figure 407,

A makes possible the oversewing of the frill of crushed duodenum. This suture is then passed in such a manner as to invert

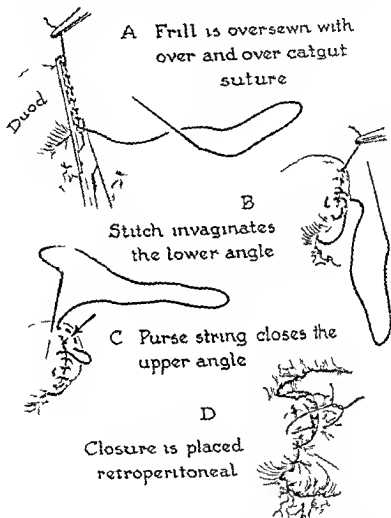


Fig 407 - Method of closing duodenal stump. After removing the peritoneal forceps from duodenal stump the remaining frill is oversewn as in *A*. This stitch then invaginates the inferior angle as shown in *B* and carried on as an over and over suture for the second layer of closure the superior angle on the upper aspect of the duodenum being closed by a purse string as in *C*. The peritoneum over the pancreas is then sutured with interrupted silk sutures to the lateral wall of the closed duodenal stump thus placing the closure completely retroperitoneal as in *D*.

adequately the inferior angle of the duodenal stump closure as shown in Figure 407 *B*, and then carried on as an over and

over suture to the superior angle of the stump where as a purse string it adequately inverts the upper angle (Fig 407 C) A few interrupted silk sutures reinforce this closure Interrupted sutures placed between the peritoneum on the surface of the pancreas and the wall of the duodenum lateral to the closure of the duodenal stump completely cover the closure with peritoneum and place it in a retroperitoneal position where the likelihood of leakage is reduced to a minimum (Fig 407 D)

Closure of the Duodenal Stump in Difficult Penetrating Posterior Wall Duodenal Ulcers

The type of closure described is made possible by adequate mobilization of the duodenum as a first maneuver. In some cases however there is present a penetrating posterior wall duodenal ulcer which makes impossible the mobilization of the posterior wall of the duodenum that is necessary for carrying out of this technic. If such an ulcer is present it soon becomes apparent as the dissection of the reflection of the peritoneum on the posterior wall of the pylorus is carried out. This type of penetrating posterior wall duodenal ulcer presents one of the very difficult technical problems in closure of the duodenal stump. However closure can be carried out successfully by means of a technical procedure whereby the base of the ulcer is anteriorized without disturbing the base where it penetrates into the pancreas. The steps of this procedure are indicated in Figures 408 and 409. The duodenum is boldly opened and divided so that the mucous membrane on the medial aspect of the ulcer is reflected. It is of the utmost importance that one should not attempt to separate the ulcer base from the mucous membrane. The ulcer is then closed in the posteromedial quadrant of the duodenal stump.

stump in the cavity of the ulcer base and again completely retroperitonealizes the closure of the duodenal stump as well as the ulcer base

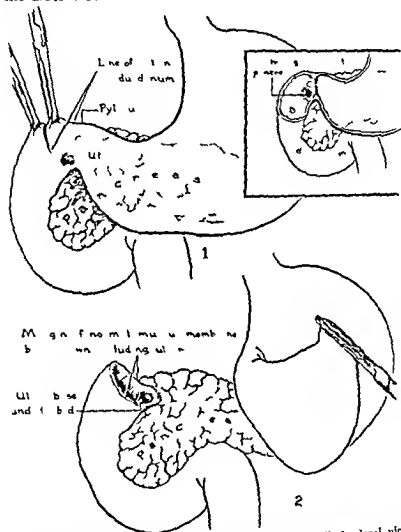


Fig. 408—1. Visualization of a penetrating peptic ulcer. The duodenum is opened fully as shown in (1). In this way all pyloric mucosa is removed and all duodenal mucosa removed from the margin of the ulcer except at the posteromedial quadrant of the duodenum. This should be left undisturbed. (Author's article in Surg. Gynec. & Obst. Vol. 66, By permission of the publishers.)

This procedure has been carried out successfully on innumerable occasions and while superficially it may seem that one is

courting disaster by locking up the infection in the ulcer base this has not been our experience in a single case. We have simply wiped off the base of the ulcer with a 1:1000 aqueous solution of terrilavine. The merit of this detail may be open

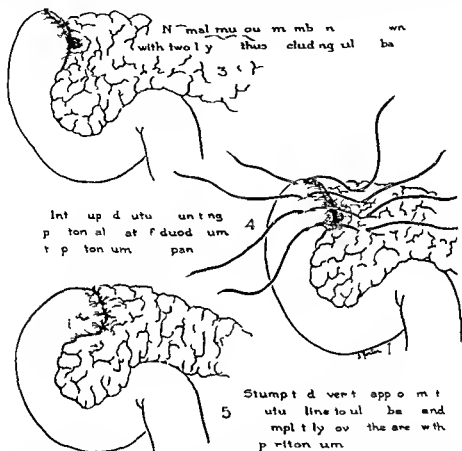


Fig 409—Exteriorization of penetrating posterior wall duodenal ulcer (*continued*). In (3) is shown the closure of the duodenal mucosa leaving the ulcer without the lumen of the duodenum. In (4) the peritoneum over the face of the pancreas is united by interrupted silk sutures with the lateral surface of the closed duodenum. In this way the closed duodenal stump is forced in contact with the ulcer base and the whole closure is placed retroperitoneal as in (5) (Author's article in *Surg. Gynec. & Obst.* Vol. 66. By permission of the publishers.)

to doubt apart from its soothing influence on the surgeon's conscience. This method of closure further has the advantage that should there be any leak of pancreatic secretion from this ulcer base it will find its way into the stump of the duodenum and thus avoid a pancreatic fistula. The manner in which this

procedure has simplified the problem of closure of the duodenal stump in these difficult penetrating posterior wall duodenal ulcers and obviated the need for technic that might result in leaving in situ gastric mucosa *has been extremely gratifying*. We are firmly of the opinion that leaving residual gastric mucosa in the pyloric antrum is definitely disastrous. From this mucosa is produced a hormone which stimulates acid production in the gastric remnant. In our experience the Finsterer gastric resection which leaves residual pyloric mucosa results in the formation of gastrojejunal ulceration.

Resection of the Stomach

Having effectively dealt with the duodenal stump one then turns his attention to the division of the stomach and removal of an adequate area. The future literature will undoubtedly contain contradictory and confusing data regarding the merits and demerits of gastric resection for duodenal ulcer. Many of these confusing and conflicting statements could be understood if the authors would state definitely the area of stomach removed. After careful observation and prolonged follow up of a large number of cases we are now convinced that a radical subtotal gastrectomy removing the entire lesser curvature and leaving only a fundic pouch is compatible with the work worry environment and diet of a pick and shovel laborer and carries with it no physiological hazards such as an anemia which cannot be controlled by adequate nutrition and sufficient iron intake. This type of resection will result as is so desirable in a higher percentage of completely anacid stomachs than any other procedure.

In the resection of a stomach for duodenal ulcer it is therefore our custom to remove the entire lesser curvature and at least three fifths of the entire stomach. The entire lesser curvature is removed because of the fact that the pyloric mucosa which carries the acid stimulating hormone often extends a surprisingly long way along the lesser curvature towards the esophagus. It thus become necessary to divide the left gastric artery high on the lesser curvature. This is made relatively easy by the production of an artificial edema along the lesser curvature by the injection of 20 cc. of 0.5 per cent novocain. This makes the separation of the left gastric vessels from the lesser curvature

of the stomach very easy as indicated in Figure 410. The triple clamp method and double ligation of the left gastric artery are carried out. This results in a very complete and free mobilization of the lesser curvature of the stomach. The site of the new gastric stoma on the greater curvature is then selected and three clamps are applied. A Schoemaker clamp is then applied as indicated in Figure 406. This permits the resection of the entire

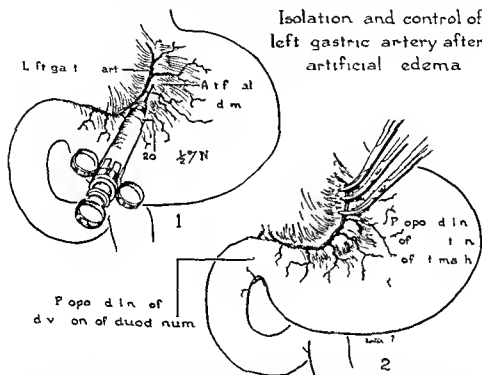


Fig 410—Isolation and ligation of left gastric artery. The injection of 20 cc of 0.5 per cent novocain produces an artificial edema along the lesser curve which permits the easy separation of the vessels from the gastric wall. Three clamps are applied, two being left on the stump of the left gastric artery, which can thus be doubly ligated with ease and safety.

lesser curvature and an adequate amount of the greater curvature and body of the stomach. The removal of the outer half of the Schoemaker clamp leaves a frill of crushed gastric wall which can be readily oversewn, closing what will become the new lesser curvature (Fig 411). After this frill is oversewn, the clamp is removed, the redundant distal portion of crushed gastric wall which remained between the blades of the clamp is amputated, and the same catgut suture is continued backwards

producing the second layer of closure of the newly formed lesser curvature. This two layer catgut closure of the new

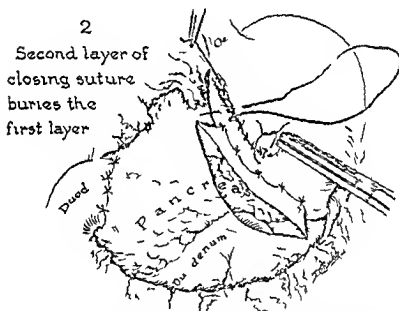
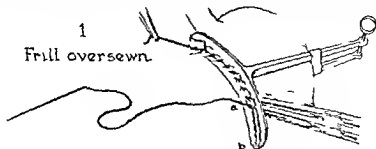


Fig 411—The outer half of the Schoemaker Imp is removed and the frill remaining is oversewn by an over and over suture (1). The clamp is then removed the redundant piece of gastric wall *a b* is amputated and the second layer of closing suture is continued as an over and over suture burying the first closure layer. A third layer of interrupted silks completes the closure. The posterior layer of the gastrocolic omentum is opened and the lateral leaf is united to the posterior wall of the stomach with interrupted silk sutures as shown in (2).

formed lesser curvature is then reinforced with a row of interrupted No. C silk sutures the upper two sutures incorporating the gastrohepatic omentum which contains the divided left

gastric artery This makes a very secure closure of the superior angle of the resected lesser curvature (Fig 412)

Retrocolic Polya Procedure in Obese Patients

If the patient be extremely obese it is wise to restore continuity of the gastro intestinal tract by means of a *retrocolic*

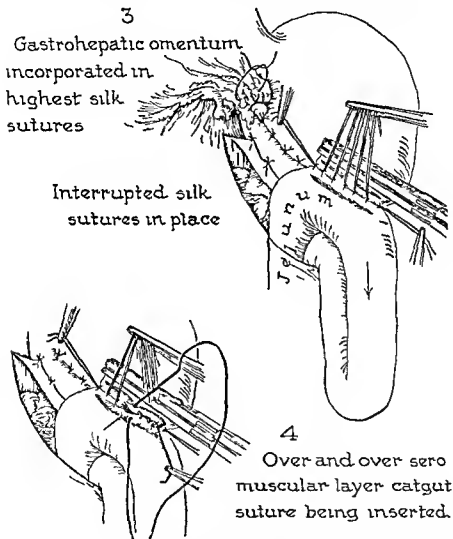


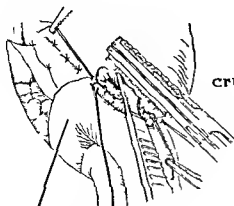
Fig 412 —Describes suture of gastrocolic to stomach Distal loop from greater curve Note stay sutures

Polya procedure An incision is made in the peritoneum of the gastrocolic omentum in a bloodless area The lateral margin of the gastrocolic omentum is sewn to the posterior wall of the stomach with interrupted silk sutures (Fig 412 3) Through

this opening is drawn the proximal jejunum which is united to the posterior wall of the stomach by a series of interrupted silk sutures the distal loop of jejunum leaving from the greater curvature of the stomach. In the placing of this layer of interrupted silk sutures one can definitely avoid axial rotation of the jejunum by placing the sutures at the upper and lower extremities of the proposed jejunal stoma as a preliminary procedure. Tension on these sutures makes possible the insertion of the subsequent sutures easily and without any possibility of axially rotating the jejunum (Fig 412 3). These sutures are left long and held in a hemostat while the seromuscular coat of the jejunum and stomach are divided (Fig 412 3). A continuous catgut suture then unites these seromuscular coats as indicated in Figure 412 4 cutting the interrupted silks as the suture proceeds. Using these silks as a source of traction facilitates greatly the accurate suture of these seromuscular layers.

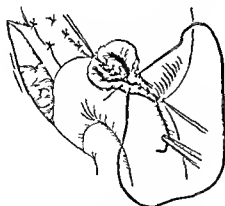
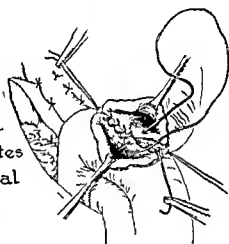
At this stage one protects the general operative field by draping which excludes all but the site of the anastomosis. We use a red denim drape which has become known as the red flag.³ This reminds us that everything on this red flag is potentially contaminated and dangerous—hence the red color. All instruments which are used in the anastomosis when the stomach and jejunum are open are discarded when these structures are again closed. The jejunal mucosa is then opened and the stump of stomach which has been crushed by the two hemostats is amputated (Fig 413 5). We are in the habit of using two clamps on the cut end of the stomach because on occasions with the use of only one it has slipped off and spilled gastric content. As the stomach is opened the assistant inserts a suction tip which removes any residual gastric content and prevents soiling. The catgut suture is now continued and by means of a blanket stitch unites the mucous membrane of the stomach and jejunum forming the posterior wall of the new stoma (Fig 413 6). This same suture is continued uniting the anterior gastric and jejunal mucosa forming the anterior wall of the new stoma. It will be found of advantage because of the redundancy of the jejunal mucosa to take two bites of jejunal mucosa on the needle for one of the gastric mucosa. This will overcome the redundancy and accurately fit these two mucous membranes together.

Continuing with the catgut the anterior seromuscular layers of the stomach and jejunum are closed (Fig 414 8) All the instruments and sponges which are then on the red flag to



5
The gastric wall
crushed by the clamps
is amputated

6
The jejunal
mucosa is opened and
the posterior layer unites
gastric and jejunal
mucosa



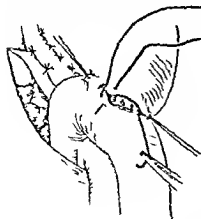
7
The same suture
unites the mucosa
anteriorly

Fig 413—The tissue crushed by the clamps on the stomach is now amputated and with a continuous catgut suture of fine chromic gut a typical three layer anastomosis is carried out

gether with the red flag itself are discarded A purse string suture is then placed enclosing the inferior angle of the gastro jejunal anastomosis (Fig 414 9) A similar purse string suture is placed at the superior aspect of the jejunal anastomosis and

reinforces the angle between the newly closed lesser curvature and the anastomosis with the jejunum. Two or three additional

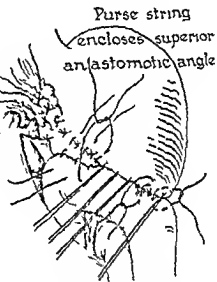
8



The catgut suture is continued to unite the seromuscular coats of stomach and jejunum.

9

Two purse string sutures fix proximal jejunum to stomach above stoma.



Purse string encloses superior anastomotic angle.



10

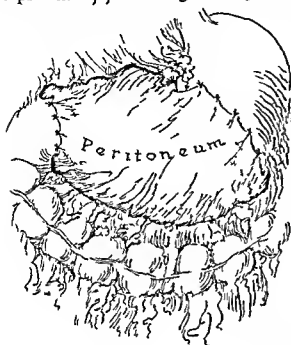
Completed anastomosis

Purse string encloses inferior anastomotic angle.

Fig 414—After completion of the serous layer of sutures purse string sutures are placed to reinforce the inferior and superior angles of the anastomosis. Three more purse string sutures are placed to anchor the proximal jejunal loop high on the newly formed lesser curve (9). This not only reinforces the closure of the new lesser curve but creates an anatomical arrangement which prevents the egress of gastric content into the proximal jejunal loop and permits ready emptying of the gastric remnant (10).

purse string sutures are placed as indicated in Figure 414 9 in such a manner as to place the proximal jejunal loop high on the

newly closed lesser curvature This has two definite advantages (1) It reinforces the closure of the lesser curvature (2) It lifts the proximal jejunum high enough up on the newly restored



11

Lateral margin
of gastrocolic
omentum sutured
to anterior gastric
wall Stomach lies
retrocolic

12

A similar
anastomosis carried
out bringing the
jejunum in front of
the transverse colon

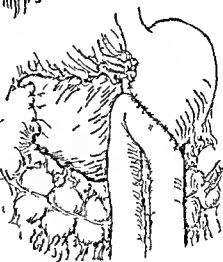


Fig 415 -The jejunum is then returned to its retrocolic position and the medial leaf of the gastrocolic omentum is sutured to the anterior gastric wall This places the entire anastomosis retrocolic In (12) a similar anastomosis may be carried out bringing the jejunal loop up in front of the colon No enteroenterostomy is necessary when the proximal jejunal loop is anchored high up on the newly formed lesser curve

lesser curvature so that distention of the stomach with food will create a valve mechanism which prevents the regurgitation of gastric contents into the proximal jejunal loop This is a

definite advantage because in certain of our patients early in the series upon whom we carried out a gastrectomy there was a morning nausea and in these patients as demonstrated by an x ray follow up there was an efflux from the stomach into the proximal jejunal loop. With this technical procedure such an efflux does not occur the stomach emptying readily into the distal loop of jejunum (Fig 414 10)

Antecolic Polya Technic in Long wasted Thin Persons

Should the patient be a long wasted thin individual it is of real advantage to carry out the anastomosis by bringing the jejunal loop up in front of the colon with the so called antecolic Polya technic as shown in Figure 415 12). An exactly similar type of gastrojejunal anastomosis and anchoring of the jejunal loop high on the lesser curvature is described previously is carried out. We feel that on the completion of this anastomosis the manual placement of the gastrojejunal anastomosis high up in the left upper quadrant is of real advantage as it makes certain that there is not a gross volume of omentum lying in the jejunal loop. No entero enterostomy is necessary when one has carried the proximal jejunal loop high up on the lesser curvature.

Closure of the Abdomen

If the dissection about the duodenum has involved a penetrating posterior wall duodenal ulcer requiring exteriorization it is now our custom to sprinkle 5 gm of microcrystalline sulfanilamide intraperitoneally. This completes the technical procedure with the exception of closing the abdomen. In the patient with massive hemorrhage or severe nutritional disturbance whose rectus muscle is split on opening the peritoneal cavity the abdominal wall is closed by a single layer of figure of 8 stainless steel wire. In the young well nourished individual who has not recently bled the abdominal wall is closed with continuous catgut in the anterior and posterior sheath of the rectus muscle both of which layers are reinforced by interrupted sutures of No. 6 silk.

CONCLUSIONS

In conclusion it may be stated that certain definite factors are essential to the successful treatment of duodenal ulcer by means of a subtotal gastrectomy namely

- 1 An adequate incision with adequate exposure of the operative area
- 2 Meticulous attention to complete hemostasis
- 3 Gentle and sharp knife dissection using the principle of tissue tension which renders such dissection bloodless and atraumatic to the greatest degree possible
- 4 Adequate mobilization of the duodenum
- 5 The principle of exteriorization applied to the penetrating posterior wall duodenal ulcer
- 6 All closed duodenal stumps placed retroperitoneally
- 7 A radical removal of three fifths of the stomach including the entire lesser curvature
- 8 The gastrojejunal anastomosis carried out in such a way that the proximal jejunal loop is held high above the newly formed stoma

Such a technical procedure carried out as a primary maneuver in the operative treatment of duodenal ulcer will result in minimal mortality and a very high percentage of cures indeed in our series we have as yet been unable to prove a single post operative gastrojejunal ulcer when we have had the opportunity to carry out this maneuver as a primary procedure the mortality being at the moment just over 3 per cent

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ARTHRODESIS OF THE HIP JOINT*

A New and Simple Operation

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OPERATIVE fusion is a valuable procedure in the treatment of certain lesions of the hip joint e.g. tuberculosis and morbus coxae senilis. When the operation is successful the improvement it accomplishes is as great as that achieved by excision of the knee joint for tuberculosis or by subastragalar arthrodesis for comminuted fractures of the os calcis. Fusion of the hip joint, however, is technically difficult and success is less frequently achieved than in other joints. There are a number of reasons for this.

Difficulties Encountered in Operative Fusion of the Hip Joint

- 1 The joint is deeply situated so that exposure is an operation of magnitude which can be time consuming and associated with considerable blood loss.
- 2 Removal of the cartilage from the head of the femur and from the acetabulum in an attempt to obtain contact of bare bone with bare bone reduces the size of the femoral head and increases the size of the acetabulum until so gross a disproportion exists between them that intimate fit and contact are lost.
- 3 It is difficult to fix the hip joint so securely that no movement occurs. No plaster spica, however skillfully it may be applied, will completely prevent movement of the patient within the plaster and such movement, however small, can be accompanied by movement of the hip joint to the detriment of the fixation necessary for fusion.

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- 4 In tuberculosis of the hip joint the opening of the diseased joint adds grave risks of dissemination of the disease and of failure of fusion. Extensive resection is necessary to secure bare bone surfaces. This can be accomplished only by extensive operation which leaves the disproportion in size between the head of the femur and the acetabulum impossibly great.

Types of Hip Joint Arthrodesis

The technical problems associated with arthrodesis of the hip joint have resulted in the introduction of many new operative procedures. Intra articular operations have been abandoned almost completely unless accompanied by some form of extra articular operation. Most of the new operations have been extra articular or partially extra articular operations. They have the great merit especially valuable in tuberculosis of the hip that the fusion is not carried out through an area of disease. In the truly extra articular operations the capsule of the hip joint is not opened, ankylosis is secured by a graft which bridges the space from pelvis to trochanter. The stress placed upon these extra articular grafts by reason of the gap they bridge is great so that frequently they break.

The most successful operations have been the partially intra articular but chiefly extra articular procedures in which the joint is opened on its superior aspect sufficiently to permit a graft to lie in contact with the femoral head and with the acetabulum and so reduce the gap to be bridged to its smallest proportions. Ischiofemoral fusion strongly advocated by Brittain¹ in his monograph *Architectural Arthrodesis* is a new attempt to solve the problem by an extra articular graft placed below the hip and bridging the gap from femur to ischium. It is too early to express an opinion upon its merit but the long gap to be bridged probably puts such a strain upon the graft that fracture will occur in a proportion of the cases.

The Importance of Fixation to Eliminate Movement

In all of the extra articular or partially extra articular operations a great problem is the achievement of adequate fixation of the hip during the period when fusion of the graft is occurring. In nearly all such operations the graft is secured by some

means (screws or sutures) to the femur and to the pelvis. Some operations attempt to fit the graft to a bed into which it locks. In neither case is the fixation sufficiently secure to prevent movement of the hip. Indeed small amounts of movement at the hip are extremely difficult to prevent. Yet unless they are prevented satisfactory fusion may not be obtained. We lack efficient means of external fixation. The great ball of soft tissue about the hip permits the patient to move about inside his own skin so that no matter how snugly a plaster spica may have been applied it cannot eliminate all movement at the hip. This important problem of movement at the hip is more responsible than is anything else for the failures to secure bony ankylosis after operation.

The problem of fixation of the hip following arthrodesis is rendered more difficult by the necessity for measures which will prevent stiffness of the knee. One of the most serious complications of hip joint fusion is a stiff knee. The combination of stiff hip and stiff knee in the same leg is extremely disabling though either alone can be compensated for satisfactorily. The exposure of the hip from in front by separation of the muscles including the upper ends of the biceps femoris and the vastus lateralis and the prolonged fixation in a plaster spica combine to invite knee joint stiffness. This can be prevented only by early movement. The origin of the rectus above the hip joint determines that flexion of the knee will transmit some of its force and movement to the hip. All these complex factors combine to make complete postoperative fixation of the hip difficult. Yet it is essential that it be fixed if a high percentage of fusions are to be attained.

The Elements of the Perfect Hip Fusion Operation

For many years it has been our privilege and interest to deal with hip joint problems and during the past eleven years the tuberculous hip joint has demanded our time and skill. We have become convinced that bony ankylosis is as important for the permanent and complete cure of the tuberculous hip as it is for the tuberculous knee. Much of this time has been spent in devising methods for fusing the hip. Slowly the conviction has grown that the elements of the perfect operation are as follows:

- (1) Some form of internal fixation which will secure the femoral

head to the acetabulum so firmly that no appreciable movement can take place during the period of fusion (2) Grafts single or multiple placed in contact with the femoral head and the pelvis and securely held there (3) If possible the grafts and the internal fixation should be placed by a simple operation (4) Provision must be made for exercise of the knee during the period of fixation in a plaster spica

ARTHRODESIS OF HIP JOINT BY MEANS OF TRIFLANGED NAIL AND BONE GRAFTS

Development of the Operation

During the long period of development of our present operation we have passed through a variety of stages Several years were spent in determining the best avenue of approach the final decision being in favor of an anterior approach As early as 1931 we were transfixing the femoral head to the acetabulum with a Wyeth pin the end of which projected through the wound and through the plaster spica This plan of transfixion fixation had proved valuable in excision of the knee joint and is still used By 1933 we had standardized our procedure to an anterior exposure of the joint through which a graft slid down from the ilium was fastened to the prepared superior surface of the head and neck of the femur with screws of beef bone The description of this operation was published together with results in twenty cases (80 per cent fused)

As the need for more efficient means of securing fixation of the femoral head to the acetabulum became apparent the operation was supplemented by the insertion of screws of beef bone through the femoral head into the acetabulum the insertion of threaded wires through the femoral head into the acetabulum the use of bone splinters as nails to secure the femoral head to the acetabulum and finally by the use of large accessory grafts taken from the tibia and placed on the anterior surface of the femoral neck and driven through a window into the acetabulum These steps improved the operation somewhat but there still was an undue proportion of cases in which fusion was not secured and such cases presented evidence that the failure of fusion was due to movement of the hip (e.g. fracture of the graft fracture of the screws which held the graft pulling of the screws out of place) Moreover the operation of open ex

posure of the joint still remained a formidable procedure time consuming not easy and not without risk to the patient

For a long time the use of Smith Petersen's nail to fix the femoral head in the acetabulum was contemplated as an accessory agent of fixation. Fear of the presence of a foreign body in a tuberculous focus made us hold our hand until the use of stainless steel wire as an agent to hold the grafts demonstrated that little was to be feared from such innocuous metal. Smith Petersen nails finally were used as adjuncts to the bone graft operation. The graft was placed through an anterior incision the nail through a second lateral incision which added to the operation. Finally the development by Gallie and Lewis³ of a technic for the treatment of nonunion of the neck of the femur by means of a Smith Petersen nail supplemented by a bone graft driven in parallel to the nail encouraged us to simplify the whole procedure of hip arthrodesis and replan it along the lines of the insertion of a Smith Petersen nail. This is the present operation described in this paper.

Technic

In outline the operation consists of the insertion (under x ray guidance) of a long Smith Petersen nail through a small lateral incision. The nail is driven through the femoral head into the acetabulum and is for the purpose of fixing the femoral head in relation to the acetabulum. Tunnels are then drilled (usually two) (parallel to the nail) through the trochanter femoral neck femoral head across the hip joint through the acetabulum into the pelvis. Into these tunnels grafts are driven. At a second stage three months later the nail may be withdrawn and the tunnel it occupied filled with another graft. Detailed step by step description of the operation follows (Fig 416).

1. The patient is placed upon the modified Hawley table used for the operation of insertion of a Smith Petersen nail in fracture of the neck of the femur. This table has the usual pelvic rest replaced by a bakelite tunnel which fits onto the perineal post and will carry a 12 by 14 inch film with its cassette in a tray which can be removed from either side. A perineal post of bakelite is attached to the tunnel. The patient's feet are fastened to the leg pieces in such a manner that the involved hip is in the midposition of abduction adduction and is flexed about

15 degrees To achieve the latter it may be necessary to place a support beneath the knee Correct position of the hip is of extreme importance Where it lies on the table will be the position of fixation There is a tendency to fix the hip in slight abduction and this must be carefully guarded against

2 With the patient upon the table in the desired position two portable x ray tubes are placed in such a manner that they may be used to take lateral and anteroposterior radiographs The use of two tubes is important It avoids the necessity of shifting a single tube between the taking of the two views simplifies the technic and ensures that the whole series of x rays will be taken in a comparable manner One tube is placed between the patient's thighs and is directed horizontally It is covered by the draping and remains unchanged in position during operation The second tube is arranged beside the patient on the side opposite to the involved hip in such a manner that the tube can be slid along the arm to hang perpendicularly over the hip in position to take the anteroposterior view

3 The involved hip and the whole of the leg on the involved side are then prepared down to the ankle (preparation of the skin permits removal of the desired grafts from the same leg) The field is draped in such a manner as to exclude the x ray tube horizontally placed between the patient's thighs and also the foot supports but to leave the hip and leg exposed If necessary a block is placed beneath the knee under the drapes to maintain the correct degree of flexion at the involved hip

4 We prefer to remove the bone graft below a tourniquet as this greatly diminishes the amount of blood lost and facilitates the operation At this stage therefore a sterile tourniquet is applied to the midthigh The Esmarch rubber bandage applied over the foundation of a flannelette bandage is best It is necessary to compress the limb below before applying the tourniquet in order that there be no engorgement and the field be completely bloodless This is accomplished by an Esmarch bandage also and this too must be sterile The steps follow (1) apply the sterile compressing Esmarch bandage from the ankle to the midthigh (2) wrap a sterile flannelette bandage snugly about the thigh just above the compressive bandage (3) apply the second sterile Esmarch bandage over the flannelette bandage (4) remove the first (compressive) Esmarch bandage

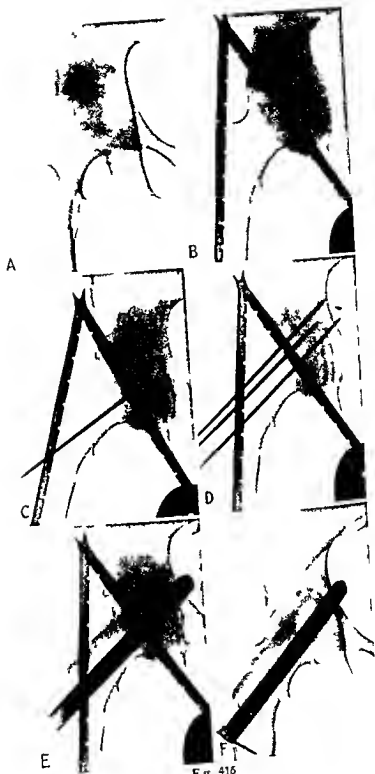


Fig 416
1418

5 The next step is to pass a guide pin along the femoral neck in the position the triflanged nail is to occupy (Fig 416 B, C) This should be slightly below the center of the neck and the pin must pass through the femoral head and the acetabulum and barely into the pelvis since this is the position the nail must finally occupy The guide pin may be inserted by any of the several methods in common use for the insertion of a Smith Petersen nail for fracture of the neck of the femur We prefer the use of Hey Groves notched protractor and guide inserting the pin through the unopened skin

6 After the guide pin has been inserted anteroposterior and lateral radiographs are taken to determine that its position is satisfactory

7 While these films are being developed the skin incisions are made (1) on the lateral surface of the thigh centered upon the projecting guide pin and (2) on the subcutaneous surface of the tibia Skin towels are applied to these incisions with Michel clips to exclude the skin

8 By this time the developed films have returned and the position of the guide pin can be seen If its position is not satis

Fig 416—A nontuberculous destructive arthritis of the hip joint resulting in a painful hip with gross limitation of movement

A Roentgenogram of the hip before operation This and the succeeding roentgenograms illustrate the successive steps in the operative procedure

B The hip after the patient has been placed on the modified Hawley table The notched protractor is in place to guide the direction of the guide pin For the sake of simplicity the lateral radiographs have not been reproduced They are taken to ensure that the guide pin is correctly placed in this plane also

C The first guide pin along which the triflanged nail will be passed has been inserted It lies slightly below the center of the neck It has not yet been driven in sufficiently far It must just penetrate through the inner cortex of the pelvis

D The first guide pin has now been driven in to the correct depth and the two upper guide pins which will carry the drills to make the tunnels for the grafts are in place Their position is correct but they require to be driven in deeper

E The triflanged nail and the two sets of grafts have been driven home and the guide pins have been removed Note that both the nail and the grafts penetrate into the pelvis This is important Unless it is accomplished the fixation is insecure The head of this Watson Jones arthrodesis nail was fixed with a transfixing pin before the wound was closed

F The end result achieved by the operation illustrated by the preceding roentgenograms This roentgenogram was taken nine months after operation The hip is solid and painless Patient is walking

factory another pin is inserted and its position checked by further radiographs until perfect position is obtained

9 When the first guide pin has been satisfactorily placed two others are inserted parallel to it and above it (Fig 416 D) one in the anterosuperior portion of the neck and one in the posterosuperior portion of the neck These must also just enter the pelvis Their position is checked by x ray until satisfactory

10 A triflanged nail of appropriate length is driven along the lower guide pin to the proper depth It is important that a nail of the right length be selected It must be long enough to penetrate through the inner cortex of the os innominatum otherwise the fixation of the hip will not be secure On the other hand it must not be too long If the guide pin is one of fixed length and has been inserted to exactly the right depth it is easy to determine the correct length of nail by measurement of the projecting end of the guide pin Either a long Smith Petersen nail or the heavier Watson Jones arthrodesis nail may be used Correct length is the important requirement It is wise to perforate the cortex of the femur about the guide pin with a cannulated drill in order that it may not be shattered by driving in the heavy nail through the dense cortex

11 The position of the nail is checked by radiograph While the films are being developed grafts are cut from the tibia One long graft exactly $\frac{1}{2}$ inch wide is cut from the center of the shin It should be long enough that when cut in two it reaches the full length of the tunnel drilled for it into the pelvis A second graft of half the length is cut from the center of the crest of the tibia

12 A $\frac{1}{8}$ inch cannulated drill is then passed along one of the superior guide pins until it just enters the pelvis The long graft is cut into two pieces the cortical surfaces carefully cleaned of periosteum and applied to one another one end of this doubled graft is then pointed and the pair are driven home in the tunnel prepared for them Being slightly larger than the tunnel they fit snugly and when driven home provide additional fixation of the hip as well as close contact with femur and acetabulum

13 A second $\frac{1}{8}$ inch tunnel is drilled along the remaining guide pin and the second graft from the crest of the tibia is driven into this tunnel The position and particularly the depth of the grafts are checked by radiographs (Fig 416 E)

14 The wounds are closed in layers, the deep structures with catgut the skin with silk

15 We have not yet felt that the fixation of the hip secured by the nail and grafts was sufficiently secure to permit us to do without plaster fixation. Without plaster the whole strain of every movement of the leg in relation to the trunk falls upon the nail and grafts and might loosen the fixation. At this stage therefore a heavy Kirschner wire is passed through the lower end of the femur a dressing placed on the shin the tourniquet removed and a plaster spica applied incorporating the ends of the Kirschner wire in the plaster

16 Two weeks after operation the posterior half of the plaster from the knee down is removed and knee flexion exercises started with the patient lying on his face. These are continued vigorously until removal of the plaster. The transfixing Kirschner wire interferes somewhat with vigorous and full knee flexion since it prevents free movement of the iliotibial band. It should be retained in spite of this for at least a month since there is no other means of preventing rotational strains upon the hip when the knee is flexed and the leg and foot are out of the plaster

17 The plaster is removed at the end of four months the condition of the fusion checked by radiograph and if satisfactory the patient allowed up

In a certain number of cases at the end of three months we have removed the plaster reopened the wound removed the triflanged nail and placed in the space it occupied a section of the fibula from the same leg. After the second stage operation no plaster is used

Results

This operation has now been performed upon twenty eight patients with very satisfactory results. In every case save one we have been successful in obtaining solid ankylosis in a period of time ranging from four to eight months. This is a much greater degree of success than we have been able to obtain with any other operation for fusion of the hip. Moreover the operation is much simpler. Two patients fractured their grafts (Fig 473) after they commenced walking but both fractures united spontaneously and now have satisfactory fusion. One patient



Fig 417—The result obtained in a *proved tuberculous hip*. A Preoperative roentgenogram in June 1941 B Roentgenogram in May 1942, nine months after operation. Fusion was solid in four months. The patient now is active has a painless hip knee flexes to 45 degrees (i.e. a range of 135 degrees)

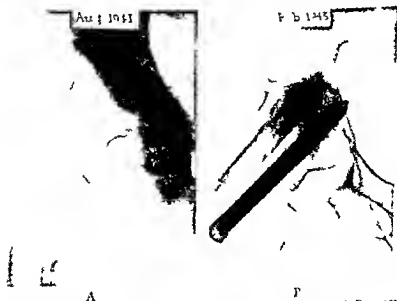


Fig 418—The result obtained in a *proved tuberculous hip*. A Preoperative roentgenogram in August 1941 B Roentgenogram in February 1943, nine months after operation. Fusion was solid in four months. hip is painless and knee flexes to 60 degrees (i.e. a range of 120 degrees)

fractured the atrophic femur just below the trochanter (Fig 424) She is still in plaster for the treatment of this fracture but there is every reason to believe that union will occur. The fused hip was undoubtedly a factor in producing this fracture since it threw stresses upon the femoral shaft which normally would be taken up by the mobile hip. It is a risk associated with every type of arthrodesis of the hip and is not peculiar to this type of operation.

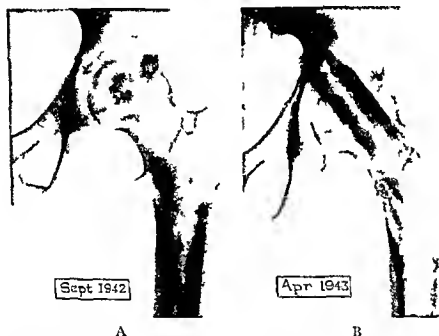


Fig 419—The result obtained in a destructive lesion of the hip of uncertain etiology possibly tuberculous. A Preoperative roentgenogram in September 1942. B Roentgenogram in April 1943 six months after operation. Hip solid and painless. Knee flexes to a point beyond a right angle. The transfixing nail has been replaced by a fibular graft.

We have found that *limitation of movement of the knee joint* is the most serious complication of this operation as it is of all operations upon the hip. The necessity for prolonged fixation of the hip and the stresses which knee flexion places upon the hip joint result in the prolonged use of plaster which fixes both knee and hip. This too often results in knee stiffness which cannot be overcome. We have found that early movement of the knee conscientiously and persistently carried out will ensure a mobile knee. In order that early knee movement may be

carried out without too great strain upon the hip we have transfixed the lower end of the femur with a heavy Kirschner wire which is incorporated in the plaster. Though this makes movement somewhat uncomfortable because of the sawing of the distal band across the wire it does permit movement to be started at the end of the first postoperative week. Knee flexion is best carried out with the patient prone. The movement should be actively performed by the patient's own muscles. Some assistance in supporting the weight of the leg may be

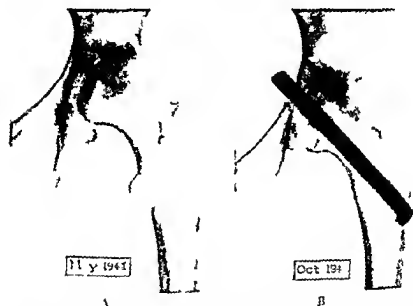


Fig. 40-71. Result obtained in a proved tuberculous hip. A. Preoperative roentgenogram in May 1941. B. Roentgenogram in October 1941, four months after operation. Light shadows of cellulose hip as sold in the hospital and completely about the joint. Knee flexes to 90 degrees. Patient is

necessary at first but it should only be assistance. Not less than 500 such knee flexions should be carried out each day and with all the energy of which the patient is capable.

Hip joints with lesions such as the traumatic arthritis known as morbus coxae senilis are easily fused by this method. The marked limitation of movement and the erosion of articular cartilage which results in close approximation of the femoral head to the acetabulum make the gap to be bridged by the grafts small. The same is true of those cases of hip joint tuberculosis



Oct 1941

A



Mar 1943

B

Fig. 421—The result obtained in a destructive hip lesion probably tuberculous though not definitely proved. The patient had Pott's disease. A Pre-operative roentgenogram in October 1941. B Roentgenogram in March 1943 fifteen months after operation. Hip solid in four months. Painless. Knee flexes to 70 degrees (i.e. a range of 110 degrees).



Feb 1939

A



Oct 1939

B

Fig. 422—The result obtained in *morbus coxae senilis secundary to dysplasia of the hip joint*. A Pre-operative roentgenogram in February 1939. B Roentgenogram in October 1939 seven months after operation. Hip solid and painless. The patient is active and does her own housework. A fibular graft was used in this case.

could be secured by means of bone grafts alone in which case three grafts spaced equidistant through the femoral head would replace the present triflanged nail and two grafts. It also would insure the maximum amount of bridging by means of grafts without replacing the nail by a fibular graft at a second operation. We are now using the method of three grafts in selected cases and should be in a position to report upon its merits in a short time.

SUMMARY AND CONCLUSIONS

1 Arthrodesis of the hip joint has value in the treatment of certain inflammatory and degenerative diseases but technical problems make its successful achievement difficult.

2 One of the most serious of the technical problems is the fixation of the hip while fusion is occurring.

3 Very satisfactory results have been obtained by means of the operation described in this paper in which a triflanged nail is used to fix the femoral head in relation to the acetabulum while supplementary grafts ensure bony union of femoral head to acetabulum.

4 The operation is simple and causes much less disturbance of the patient than does the usual open exposure of the hip through an anterior approach.

5 Provision must be made for early knee joint movement.

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SURGICAL TREATMENT OF TUMORS OF THE SALIVARY GLANDS*

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For many years the majority of surgeons have been content with local removal of tumors of the salivary glands. The methods employed have been simple enucleation outside the capsule, enucleation within the capsule, and enucleation within the capsule with subsequent removal of it. These operations which in view of a reported recurrence rate of from 15 to 45 per cent must be regarded as inadequate have probably been continued in part because those who failed to follow their cases over a period of years acquired too optimistic a view of the results that were being obtained. In addition it seems in general to have been accepted that the relation of the facial nerve to the parotid gland was such that more radical procedures would almost inevitably result in serious injury to it. Actually the facial nerve does not in the majority of cases run through the gland. Occasionally the primary divisions may be surrounded by gland tissue for a very short distance. The usual relations have been described recently by Hamilton Bailey. Illustrations from his article have been reproduced in Figure 427. It will be seen that the main trunk of the nerve lies behind and superficial to the deep portion of the gland. The main divisions pass around the constricted portion of gland which joins the smaller deep and larger more superficial mass and break up into numerous branches which lie deep to the parotid upon the fascia of the masseter muscle. The anatomical arrangement is such that a dissection of the facial nerve preliminary to excision of tumors is not only possible but indeed with a little experience relatively simple.

The other factor that has made surgeons fear more radical procedures seems to have been a belief that cutting into a

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salivary gland was likely to result in a troublesome fistula. Actually in these as in other similar secretory glands a permanent fistula probably never forms unless a relatively large duct is divided in such a way that this wound provides the most ready or perhaps the only egress for secretions from a portion of gland distal to the injury. It has been customary in this surgical center for many years to excise the lower part of the parotid to facilitate exposure in doing block dissections of the neck for malignant disease. No fistula has ever resulted; indeed it is rare to recognize any leakage of secretions. Small bits of gland have been left without any duct connection in radical resections for tumor without the production of a fistula. It is presumed that such small portions of gland tissue simply atrophy and undergo replacement by fibrous tissue.

RECURRENCE

Two reasons are given for the frequent recurrence of these tumors: first, failure to remove a small portion at a point at which the capsule was incomplete or more firmly attached; and second, the presence of small unrecognizable seedling tumors beyond the capsule. There is in most cases one point at which the capsule is more firmly attached and particularly if it be very thin it is almost impossible to do an enucleation without breaking into the tumor. This probably accounts for the majority of recurrences which are recognized first as simple areas of thickening in the operative scar. That there is in some cases a multicentric origin is suggested by recurrences which may appear years after the original tumor was removed in the form of multiple small nodules. Two such cases occurred in this series in one of which the first nodule was noticed twenty-five years after the removal of a simple mixed tumor.

It is reasonable to suppose that all recurrences that result from failure to remove completely the original tumor could be prevented by substituting for the local operations a procedure in which the tumor together with a rim of apparently normal tissue is removed. It is probable that seedlings which lie close to the capsule would be included in the surrounding tissue but quite conceivable that some recurrences would still result in those cases in which there is a second center of origin at a considerable distance from the original growth.

In the case of benign tumors which have a tendency to recur locally only a liberal excision of the tumor with $\frac{1}{4}$ inch of surrounding apparently normal tissue is probably sufficient. When dealing with definitely malignant lesions the whole gland should be removed. From a clinical viewpoint tumors that have been present for a relatively short time and have enlarged fairly rapidly and those of long standing but with a recent more rapid increase in size should be regarded as possibly malignant. It is unfortunately impossible for the pathologist to be dogmatic in his opinion as to whether a growth of the mixed type is benign or malignant. That this is true has been demonstrated by McFarland in a recent article.⁵ The only incontrovertible evidence would seem to be the presence of metastases. The finding of enlarged lymph nodes should arouse suspicion. If there is doubt it is wise to excise one for quick section during the operation and if invasion by tumor is found a total parotidectomy should be done along with a removal of the lymph glands of at least the upper part of the neck.

It seems to be assumed generally that recurrences following incomplete operative removal are more likely to be malignant. Patey⁶ stated that he knew of no reported case of carcinoma of the parotid in which the evidence that it had developed from an undisturbed mixed tumor was complete. Perrin⁷ has reported one such case. A survey of our cases does not seem to support this assumption; indeed recurrence following local removal was prompt in the majority of the malignant cases and it is probable that they were malignant when operated on. If this statement should be true it ought to be accepted as evidence in favor of the early adequate removal of all such tumors rather than the reverse. This is certainly the reasoning that is applied in the case of all other neoplasms.

RADIOOTHERAPY

For a time it was hoped by many that radiotherapy would relieve the surgeon of his responsibility for the management of parotid tumors. The passage of time and increasing experience have dissipated this hope. Parotid tumors are as a group highly radioresistant. I know of no instance in which a cure has been accomplished by radiation alone and have seen little evidence that it has a marked palliative effect. On the contrary some

lies is indicated. The great auricular nerve which runs along the posterior part of the field should if possible be preserved since division of it results in an unpleasant loss of sensation about the ear.

The operation is performed under general anesthesia administered through an intratracheal catheter. Drapes are applied to leave an adequate exposure including the lower two thirds of the ear in order that anatomical relations may be preserved. The incision is started over the base of the mastoid process in the furrow behind the ear and carried downward and forward for a distance of 3 inches or more. In some small tumors this incision is sufficient but in most instances and in all large or malignant cases a second incision is made from just in front of the pinna to join the first below the ear. The angle formed at the division of the Y should be obtuse and not acute otherwise sloughing may occur. The upper portion of the first incision is deepened and the great auricular nerve identified and retracted. The anterior border of the sternocleidomastoid muscle is exposed and a part of its attachment to the mastoid process freed to permit of retraction to expose the posterior belly of the digastric muscle.

The tumor is more easily displaced if at this stage a flap of skin be turned forward from its surface. Since the facial nerve fibers lie deeply in this area there is no danger of injuring them. The tip of the styloid process and the transverse process of the axis may now be felt. Dissection is carried upward along the anterior border of the digastric by the blunt method to expose the main trunk of the facial nerve at or just anterior to the stylomastoid foramen. If the tumor is wedged between the jaw and the mastoid process exposure is improved by removing a portion of the process with an osteotome. No traction or undue force may be used as the nerve is of course absolutely fixed at its origin. Dissection is now carried forward the various branches of the nerve being identified. If the tumor is large and in all malignant cases it is wise to tie the external carotid artery before proceeding further. This lessens bleeding from the many small vessels in the area and removes the chance of damage to small nerve filaments in the attempt to catch the bleeding points adjacent to them.

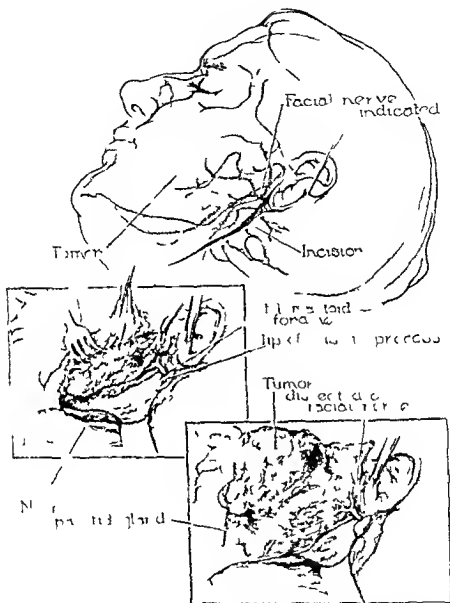


Fig. 46—Drawings made in the course of removal of one rather large benign tumor. The peculiar manner in which the facial nerve often varies in size and anastomoses with itself is shown. It is apparent that when such an exposure has been accomplished as much gland as desired may be removed about the tumor.

Before deepening the incision in its lower portion to permit of exposure of the artery it is wise to identify and free the inframaxillary nerve lest it be divided inadvertently at this

point. If the tumor is apparently benign and lying superficial to the nerve the fibers are dissected far enough anteriorly and the tumor and gland tissue lifted forward to permit of excision of the growth with a liberal portion of surrounding normal tissue. If the growth is apparently malignant any fibers which appear to be entering it are sacrificed, no attempt being made to preserve them. In definitely malignant lesions it is probably wise always to do a total parotidectomy. Those cases in which the tumor lies deep to the nerve fibers are much more difficult

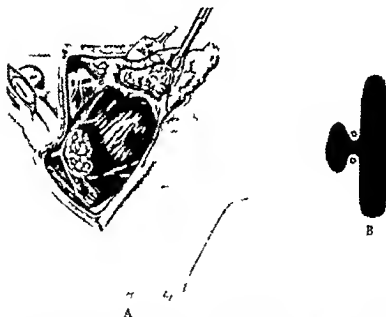


Fig. 427.—In *A* the parotid has been dissected at the neck and the body turned forward and upward from the nerve. *B* is a diagrammatic representation of the relation of the upper and lower divisions to the neck of the gland. (Redrawn from Hamilton Bailey.)

but by careful dissection of the nerve fibers to a point well anterior to the mass it is usually possible to deliver it between the fibers without producing more at any rate than a temporary paralysis.

When the dissection has been completed the deeper portions of the wound are approximated with a few interrupted catgut sutures and the skin closed with interrupted sutures or clips as may be desired. If the dissection has been difficult a greater or less degree of temporary facial palsy is likely to result but in

no case in this series have fibers which were not deliberately sacrificed failed to recover. A small amount of permanent paralysis of the lower lip due to inadvertent injury to this branch has been fairly frequent but it is so slight in most instances as to be difficult to recognize.

RESULTS

During the past nine years twenty five benign parotid tumors of which there are records have been removed by this method. Each successive resident has learned the technic and is following it in his practice. In only one instance has the facial nerve been divided accidentally. This was in the case of a neurofibroma which arose from the facial nerve immediately beyond the styloid foramen and was mistaken for a parotid tumor. Subsequent pathological examination showed that the fibers of the nerve were intimately involved in the growth and that preservation of it would have been impossible. An immediate suture was carried out and at the end of eighteen months about a 50 per cent recovery had taken place. The man is now a sergeant in the Canadian army overseas. Five of these tumors lay deep to the nerve. Six of them were recurrences following one or more previous local excisions. Two of the recurrences were in the form of multiple rather widespread nodules and in these a total removal of the gland was done. Twenty one cases have been followed and have no recurrences, four are untraced. One small malignant mixed tumor thought to be benign at the time of operation and removed with surrounding normal gland in November 1938 has not recurred.

Three total parotidectomies for lesions known at the time to be malignant because of previous interference have been done. One malignant lesion operated on in June 1940 has not recurred. One recurred at the end of four years. One recurred at the end of three years with a local recurrence in the scar. This was widely excised in November 1941 and has not returned. In the case of two additional lesions of enormous size it was necessary to sacrifice the whole facial nerve because the main trunk was involved in the mass just at the foramen. One of these has recurred and in the case of the other the result is in doubt since the operation was done only four months ago. When the whole nerve has had to be sacrificed the plastic

operation described by Lodge may be useful in decreasing the disfigurement (Fig 428)

It is of course realized that the results of any surgical removal of salivary gland tumors can be judged only through a careful follow up of a considerable group of cases over many years because of their known tendency to recur after long



Fig 48 Lodge's technique for relief of deformity from facial palsy. A strip of fascia lata is placed from the angle of the nose to encircle the internal palpebral ligament at the inner canthus of the eye thence beneath the eye to emerge at the temple where it is fastened along with the other end of the strip placed as shown in the diagram (Redrawn from Hamilton Bailey)

periods of time. It is felt that the results should be improved by a really adequate operation. There would seem to be little sound surgical argument in favor of a wait and see policy, or any of the methods which would certainly not be employed in the case of tumors elsewhere in the body if they had the same known tendency to recur.

SUMMARY

1. A safe and once the technique has been acquired a relatively easy operation for the complete removal of salivary gland tumors has been described.

2. There is at least some doubt as to whether operation makes

mixed tumors more liable to malignant change but if this is true it is an argument in favor of their early complete removal

3 Total excision of the parotid without injury to the facial nerve is possible and has been done on several occasions

4 Radiation of parotid tumors should be done only if they are beyond hope of surgical removal and palliation only can be expected Postoperative radiation of malignant lesions particularly the carcinomas is probably indicated

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WHOLE SKIN REMOVAL AND REPLACEMENT*

An Operative Procedure of Value for the Salvage of Skin Undermined by Trauma or for the Recovering of Areas from Which Resection of Extensive Subcutaneous Tissue Has Been Necessary

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Regt. C. d. A. F.

THE deliberate complete removal of massive amounts of skin and subcutaneous fat with the subsequent replacement of the skin after fat removal is an operation which is used too infrequently. The reason would appear to be unfamiliarity with the principles, the indications or the technique. Possibly the surgeon who has cases in his care which would benefit by such treatment does not feel proficient to handle full thickness skin grafts. There is nowadays every reason to expect complete success provided that certain principles are followed.

On the basis of the comparatively large number of lesions successfully dealt with by the technique of skin removal and replacement in our own surgical work, it is apparent that the method is not receiving full consideration in the treatment of similar lesions encountered elsewhere. For this reason and because of advances in treatment particularly of extensive soft tissue injuries often complicated by compound fractures a detailed report is made of the indications and methods employed. The illustrative material is drawn from traumatic and non-traumatic cases.

INDICATIONS

In traumatic lesions the primary indication for the complete removal of skin and its conversion into a free full thickness graft occurs when skin has been avulsed and there is doubt regarding the continued viability of the flap. Death of the flap may be threatened by the existence of a narrow pedicle or one which is directed opposite to the usual blood flow. Very extensive

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undermining or contusion of a flap or its attachment resulting in thrombosis of its main vessels is also a cause of rapid necrosis. In other instances late nutritional disturbances in flaps may result from suturing them under too great tension. Tension may increase due to edema of the underlying tissues or to the collection of exudate or blood beneath the flap. This is particularly fatal when the circulation originally showed signs of impairment. Contrariwise when the skin is sutured with complete lack of stress so that ordinary stretch is not maintained a contracture effect results and the circulation similarly is impaired. A skin flap also may be unfavorably influenced by infection. With the above conditions present or considered likely to occur flap removal and whole skin replacement are advised.

A section of the flap may be so badly abraded that a partial thickness graft obtained from a remote donor site is necessary as an adjunct. Relaxing incisions made in cases in which swelling is too great for primary suture may also be covered with partial thickness grafts.

Accidental wounds are all potentially contaminated. With early thorough cleansing and debridement many wounds may be closed tightly. This is particularly true when the patient continues under the observation of the same surgeon who has performed the operative work. The technic of removal and replacement can be advised in all such cases. Potential contamination is no contraindication so long as the prime indication (possible death of a skin flap from circulatory disturbance) is present. Such surgery might be considered mutilative by the uninformed. Our cases were carefully picked, proper facilities were available and close postoperative observation was possible. The results without exception have been excellent.

The indication for the removal and replacement of whole skin in other than traumatic cases occurs when such extensive undermining of skin and subcutaneous tissue is necessary that there is doubt regarding the viability of the skin. This undermining is unavoidable when much tissue adjacent to or invading the subcutaneous fat is removed.

THE OPERATION

When suitable anesthesia has been given the skin surrounding the lacerated area is cleansed with water and a sterile solution

of a soft soap. The wound is flushed with a large quantity of normal saline solution during the process of debridement. This flushing is facilitated by having a large container joined to a small tube and allowing the saline to flow continuously. Thus foreign matter and loose tissue are carried away. As in connection with the removal of a flap when doubt arises concerning the viability of a portion of skin it should be removed. It is better to remove more rather than less than the minimum required for good results. The results have been so good from generous removal as to leave no excuse for a too conservative excision which leaves a large area of dead skin attached. Sloughing delays healing, predisposes to infection and leads to a late plastic repair after granulation has set in which is not as satisfactory as a proper initial procedure.

The question arises as to why the flap should be cut free. Why not make a full thickness graft in situ leaving one edge attached? The answer is that the operation can be conducted more expeditiously if the flap is cut free. While one surgeon carries out the cleansing and debridement another prepares the graft. In badly rolled limbs with compound fractures this is an important factor. The operation is long and tedious enough without making it more difficult. Also to be considered is the poor circulation in a flap retaining a connection when it is converted into a full thickness graft. The blood flow in such a flap is very unequal. The vessels for some distance from the attachment become filled with blood and the area becomes deeply cyanosed. In our experience such a result is not as satisfactory as the complete removal and replacement of the graft.

When the flap has been removed it is prepared while the assistant continues with the cleansing and debridement of the recipient area. The freed flap does not need to be handled carefully. This is not to indicate that one should be rough with it but no delay should be occasioned by a false conception that skin is easy to kill. Forceps with or without teeth do more damage than the gloved hand. It is placed on a flat surface with the adipose tissue facing upwards and scraped with a knife until the under surface of the dermis is exposed. It is necessary to do this vigorously in order to remove the fat as thoroughly and quietly as possible. Curved scissors may be used with advantage particularly along the edges. This procedure is facili-

tated by continual flushing with normal saline to wash away free particles of fat. If the shape of the flap removed is not distinctive enough to make its position on return easily discernible, scratch mark two or three points before the original removal so that it may be fitted accurately later.



Fig 4-9—*A* Wringer injury, preoperative. This arm was rolled and badly contused and lacerated. The skin and subcutaneous fat were removed from the whole of the inner aspect and then replaced. *B* Two weeks postoperative. Despite the fact that the skin had been seriously contused as noted above the "take" was practically perfect.

The next step is the return of the skin to its former position. This is only occasionally contraindicated as when the bed in which it is to be placed is not deemed satisfactory. Bone, particularly in relation to a fracture site, needs covering with other tissues. These can be obtained usually by tissue maneuvers,

(e g relaxing incisions) the graft being placed at a more distant site Interrupted or running sutures may be used The latter are more quickly applied and time is often a very real factor

THE DRESSING AND POSTOPERATIVE CARE

In many ways the further conduct of the operation is the most important part of management The primary dressing must be applied smoothly and firmly and be retained in its original position for some days If no fracture requiring splinting is present it may be taken down in two or three weeks There is a great temptation to take a look This should be suppressed unless there is some special indication If the injury is complicated by a fracture needing maintenance of position the original dressing may be left until the usual time (weeks or months) for bony union In none of our cases within the past five years has it been necessary to examine the original wrapping early An unexplained high fever discharge or foul odor would be an indication Further treatment would be guided by what was found

The primary dressing in all our cases has been made of long wide strips of gauze soaked in normal saline solution Large strips are used because they can be put on without folds and wrinkles The wet gauze conforms more closely to the unevenness of the region and when it dries acts as a splint It is overlaid by absorbent cotton pads also soaked with saline solution This dressing is bandaged firmly into position with bias flap netlette bandages These have a degree of elasticity which give pressure Over this is placed a plaster cast to ensure immobility and discourage meddling In recent years all patients have had prescribed a sulfonamide by mouth or one by vein In no cases has one been placed in the wound

It is agreed that other materials may be just as satisfactory for the primary dressing as that discussed Our purpose has been only to describe one satisfactory method with which we are familiar

A tourniquet has been used in cases of limb injury where possible since it facilitates the operative work It is loosened during the operation to allow identification of large vessels and then reapplied The firm bandaging is finished before it is finally



Fig 430—Stages in application of head dressing

removed. All capillary oozing can be ignored if the above sequence is carefully followed.

Injuries of the face in children have been treated in the man

ner shown in the illustrations (Fig 430) A dressing is cut to fit the area accurately Occasionally it is sutured on by overlying with fine (No 34 or 36) stainless steel wire An ophthalmic ointment and eye pads are used for the eyes The surround



Fig 431—Tumor of face A Preoperative B postoperative

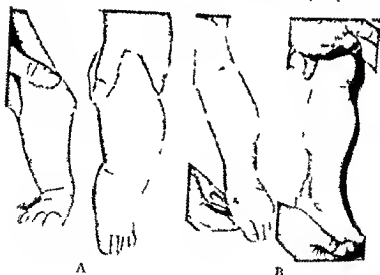


Fig 432—Fatty tumor of leg A Preoperative B postoperative

ing area is painted with mastisol A sterile stockinette headcap is passed over all and tied at the top to exclude the hair It is made adherent to the skin by the mastisol and further reinforced by an elastic adhesive bandage about the head and over the grafted area for firm pressure The nose and mouth areas are cut out

and the edges turned back and fastened with adhesive. This dressing will not slip even on a restless child. Indeed the children do not need any restraint.

The principle of extensive removal and replacement of skin has been used in other than traumatic cases. In two instances growths present at birth had enlarged slowly into widespread infiltrating fatty tumors. In one of these occurring on the face an attempt was made to cut flaps to expose the tumor for its removal. This operation was abandoned. At a second operation a large section of the skin of the face was cut free, the tumor removed and the skin replaced. The result is shown in the illustrations (Fig. 431). The scarred area beside the nose near the inner commissure of the eye resulted from the necrosis of a part of an attached flap at the first operation. The bolder procedure was completely successful. In the second instance a tumor of the leg was dealt with in two stages, after widespread removal of the skin and later replacement (Fig. 432). It was the only manner in which a satisfactory operative result could have been obtained.

CONCLUSIONS

1. The principle of widespread removal and replacement of skin is too little used.
2. Complete success depends on extensive detachment of skin flaps, thorough removal of adipose tissue, proper preparation of the recipient area and a suitable well maintained dressing.
3. Such operations are advised only early after the injury before infection is established.
4. Such operations are tedious and prolonged and require suitable operative facilities and postoperative care.
5. Outstanding successes without necrosis of tissue, sloughing, secondary infection or prolonged hospitalization are obtained.

LUNG ABSCESS*

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and

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ALTHOUGH lung abscess is an uncommon disease it is of extreme interest to both internist and surgeon because of its associated high mortality. Reports from various clinics indicate that this high mortality has not been modified to any great degree for many years. Under medical care the mortality is approximately 30 per cent and under surgical care about 45 per cent. The surgical mortality depends on the fact that cases are referred to the surgeon only when medical care has proved ineffective and usually after many months of treatment so that in these cases complications are apt to ensue.

CLINICAL CONSIDERATIONS

Etiology

Commonly abscess of the lung presents itself following some surgical procedure especially tonsillectomy or tooth extraction. It may however follow other operations and we believe it is then probably due to the aspiration of septic material from the mouth during anesthesia. Lung abscess may be embolic in nature with emboli arising from an operative field in any part of the body. It may also occur following a pneumonia either of the lobar or bronchopneumonic type. Strangely enough there are a considerable number of cases for which we can find no etiology.

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Prognosis

Lung abscess may be divided broadly into two groups—the *putrid* and the *nonputrid* forms. This clinic will deal mainly with the putrid type of lung abscess which is usually due to aspiration and in which the organisms present are numerous and of great variety containing many anaerobes. The nonputrid type usually contains but one or two varieties of organisms is much more insidious and the symptoms progress gradually. In any statistical study proper allowance must be made for the type of abscess present.

Any classification of abscess however is artificial and the prognosis cannot be given with complete assurance on this basis. At one time we made extensive studies of the bacterial flora in the hope of finding some prognostic criteria from this evidence. Two or three years were spent without positive results. The symptoms of abscess are also quite variable and change rapidly from time to time so that at any one moment it is difficult to make a definite prognosis. In general however those abscesses which are not putrid give a lower mortality and respond more quickly and satisfactorily to medical procedures including treatment with the sulfa drugs. On the other hand a certain proportion of putrid abscesses also respond to this treatment and the patients recover without operation.

Treatment

It is generally accepted that about one third of all abscesses heal under *medical treatment*. It is only fair to remember that one never knows whether a particular case belongs to this group. This has led both internists and surgeons to delay active interference in the hope that a cure will be obtained by the expectant method. In a previous paper¹ we pointed out the serious consequences of delayed operation. The tendency since that time among surgeons has been for earlier operative interference but this policy needs more positive observance. This holds good especially for the putrid abscess where the tendency to resolution and cure is not so great. A longer delay can be advised for the nonputrid type.

The medical treatment has been based mainly on rest in bed, postural drainage, administration of sulfa compounds, transfusions and at times intravenous therapy of alcohol or sodium

benzoin. With others we have discarded the use of pneumothorax as a form of treatment because of its uncertainty and the danger of fatal empyema.

Neuhof and his colleagues have been the exponents of early operation in one stage and their results certainly demand attention. Other clinics follow similar procedures. The one stage operation for abscess is very satisfactory in expert hands requiring as it does the close cooperation of surgeon and roentgenologist but it can never be advised as a general procedure for the surgeon who operates on the chest infrequently. It requires accurate localization and if the incision is made outside of the area of adhesions this is closed and a new incision made directly over the adherent lung.

Neuhof believes that all abscesses are peripherally placed and that there are early a few adhesions between the parietal and visceral pleura through which one may enter the abscess safely. If a spell of coughing takes place during the operation and after the rib has been removed these adhesions may separate and an empyema result. Even in old abscesses we have found that there may be practically no adhesions surrounding the abscess and it becomes necessary to produce an adhesive area before the abscess is opened. We therefore prefer as a rule the two stage operation in which the parietal pleura is uncovered by the periosteal dissection of one to three ribs over the localized abscess and a paraffin pack is used beneath the stripped ribs to produce the necessary pressure and adhesions. This pack is left in place and the wound closed completely. The paraffin pack is left in from five to ten days when it is removed the ribs resected and the abscess cavity unroofed by cautery after assurance is had that the pleural cavity is well walled off. The first stage is usually performed under local anesthesia and the second stage without anesthesia.

There are patients with fulminating lung abscess who enter the hospital very sick with dyspnea cyanosis rapid pulse and high temperature. These cases often end fatally regardless of the form of treatment. Occasionally operation has been successfully performed in them however and we have been especially successful in those in which gangrene of the lung with an enormous empyema was present and almost the entire lobe has been found floating in the empyema cavity.

In some cases of old abscess in which we have operated on entering the cavity we have found a large putty like mass in the center. In some of these chronic cases too we have seen small aneurysmal vessels across the field. It is advisable to tie these off as they are very likely to break and cause severe and fatal hemorrhage.

After treatment

We believe that the usual after treatment of lung abscess is unphysiologic. We are strongly of the opinion that the use of tubes and gauze packing is deleterious. We cannot improve upon nature's processes. As in the abdomen the use of these materials prevents nature from participating in the healing. We believe that surgeons in the future will not use the various forms of drainage in lung abscess now in vogue and that more and more we will dispense with these so called aids just as we have in our abdominal cases. The necessity for secondary operations for closure of the cavity in the lung after the infection has been allayed is largely the result of our continued use of packing which creates a fibrous ring around the cavity and prevents collapse. It is our policy to clean out the cavity well by suction and the insertion of a sulfa paste composed of sulfanilamide, sulfathiazole and pectin. This can be inserted every day instead of the gauze pack.

Complications

The complications of lung abscess usually occur late in its course and are preventable by early operation. These complications consist of the formation of multiple abscesses in the same or in the contralateral lung, brain abscesses from septic emboli, air emboli, hemorrhage and finally bronchial changes which decrease the efficiency of the lung's natural drainage with the production of bronchiectasis and fibrosis of the lung. This fibrosis creates the necessity for a secondary operation to close the cavity by a muscle flap or other procedure. The early operation minimizes all these serious complications and if promptly applied it should in the future lower the mortality of the surgical treatment of lung abscess.

Comment

Most cases of lung abscess are in the hands of the general practitioner who unfortunately often follows a waiting policy since the course of the disease is very variable and there are periods when it seems the patient will recover by the expectant plan. As a result most of the cases that the surgeon sees are late cases and the problem is more or less complicated. Patients are very ill, septic and toxic. Blood transfusions must be given and careful preparation made before surgery. We might compare the present treatment of putrid abscess with the treatment of appendicitis in the past. We now know that a certain number of cases of appendicitis will resolve without surgery but we have learned also that if we wait for all to do so we will have a high mortality among those that do not progress so favorably. We must now realize that in order to lower the mortality of putrid lung abscess patients must be operated upon early, often times two to three weeks after the onset, certainly not longer than six weeks.

In our experience the *sulfa* drugs when employed in putrid lung abscess may bring about improvement and thereby delay an operation but usually they do not cure and a late operation is eventually required. In the nonputrid abscess we are prone to push the *sulfa* drugs to the limit and to delay surgery a longer time before advising surgery. Those abscesses due to bronchial pneumonia or to a broken down embolic process in the lung are usually milder and contain a single or at most few varieties of organisms whereas the putrid abscess contains a multiplicity of organisms with many anaerobic bacteria. This infection is very destructive and only a few hours are required for the necrosis of the parenchyma of the lung and the smaller bronchi. Even though there is no fluid level because the bronchus has not been broken into there is early cavity formation. The removal of this nidus of infection allowing the air to enter the cavity from the outside has a most beneficent result on the anaerobic infection. In very chronic cases and those that have been neglected frequently with multiple abscesses, fibrosis and bronchiectasis the best solution to the problem is *lobectomy*. The mortality in these cases by the ordinary surgical technique is however very high.

Conclusions

It is emphasized that early in the course of the disease we must attempt to classify lung abscesses as putrid or nonputrid. The putrid abscess must be operated upon during its early stages. The sulfa drugs and other medical measures may be used in the putrid abscess for a short time but if resolution does not occur and improvement does not take place early operation is the method of choice. In the nonputrid abscess on the other hand more time may be allowed for medical treatment and use of sulfa drugs but if the condition of the patient deteriorates operation should be advised immediately. The great crime in the treatment of lung abscess is to allow so much time to elapse that the condition reaches a chronic state.

CASE HISTORY

A C a white male fifty three years of age entered the hospital September 6 1937 because of cough of four months duration. He stated that he had caught a cold while working in the rain which left him with a dull pain in his right chest. The cough persisted and his wife noticed that his breath was foul at times. Although he did not feel especially ill he quit work on the advice of his physician. He then visited the clinic where he underwent x ray examination and bronchoscopy. Hospitalization was advised but refused. Later when his sputum increased in quantity and a small hemoptysis occurred he consented to hospitalization. Past history was noncontributory.

Examination revealed a well developed and nourished male some what pale but in no acute distress. Temperature pulse and respirations were normal. The patient's lung fields revealed a few crepitant rales over the right upper portion. His heart was slightly enlarged and his blood pressure was 145 systolic and 90 diastolic. He was producing daily approximately 1 ounce of foul sputum which contained elastic tissue and was negative for acid fast organisms. Further laboratory work showed a mild secondary anemia. His blood was Wassermann negative.

X ray examination showed an infiltration and consolidation of the right upper lobe with a small area of excavation with fluid level approximately 4 cm in diameter (Fig 433).

Bronchoscopy showed the right upper lobe bronchus to be draining thick purulent material. No ulceration or tumor was present.

Neosarsphenamine was given twice weekly and patient received a blood transfusion. On September 17 1937 under local anes

thema the right third fourth and fifth ribs were exposed in the axilla and a 3 inch segment of each exposed subperiosteally. The parietal pleura was held against the visceral layer by packing beneath the exposed ribs. The wound was closed. Following this procedure the patient's general condition remained good and his sputum was somewhat decreased in amount. Seven days later the pack was removed revealing a small opening in the pleura through which purulent material was draining. The pleura was adherent only in a small area however so that it was coagulated with the cautery and the wound repacked without opening into the abscess cavity. Fourteen days after the first stage the lung was entered and a large cavity encountered. This did not resemble an abscess and x rays



Fig. 433—A C X-ray examination on a basis on showing an infiltration and on a later view of the right upper lobe with a small area of consolidation. The diameter of the cavity is approximately 4 cm.

the following day revealed the original cavity medial to the operative sight. On October 6 the large thick walled abscess cavity was untapped. This contained foul purulent material and communicated with a bronchus on its medial wall. A culture of this material was reported to contain aerobic nonhemolytic *Staphylococcus aureus*, anaerobic streptococci, gram negative filaments and gram positive bacilli.

One week later the patient developed a fever. The sputum increased in amount and after another week another abscess cavity above the former was drained. Drainage and sputum gradually decreased and the patient was discharged from the hospital with only a small draining sinus on October 24, 1931.

He was followed at the clinic and the wound was seen to close prematurely. He continued to cough and x rays revealed residual cavities at the original site (Fig 434). He again entered the hospital on January 1, 1938, when a two-stage drainage was done. Two communicating abscess cavities which contained thick putty like material were drained and a bronchial fistula was cauterized. His chest wound healed rapidly and was enlarged on March 11, 1938. He was again discharged to the clinic.

He felt well and gained weight but continued to produce about 1 ounce of sputum daily. Five months after discharge he coughed up a small amount of blood and re-entered the hospital for study.

On entry to the hospital his previous wound was healed. X ray examination with lipiodol revealed some bronchiectasis of the right



Fig. 434—A. C. Residual cavities are seen at the original site of operation.

upper lobe and two cavities at the site of the previous abscess (Fig 435). On August 17, 1938, his pleural space on the right side was explored with the view of performing a lobectomy. However, the right upper lobe was densely adherent to the thoracic wall, whereas the middle and lower lobes were held by only a few filmy adhesions. The pleural space was closed at this time and three days later a large cavity was unroofed, exposing also the smaller cavity visualized with lipiodol and a large bronchial fistula.

The cavities granulated well but the fistula persisted so that on October 28, 1938, a muscle flap was prepared for insertion into the fistula. This procedure was carried out under nitrous oxide and oxygen anesthesia. Just as the flap was ready for insertion into the

cavity the patient's general condition suddenly became very poor. His respirations were shallow, pulse and blood pressure imperceptible. Transfusion was started, the wound was hurriedly closed and



Fig. 435—A. C. Senior, 1915, after a late stage drainage. Bronch ectasis of the right upper lobe and consolidation at the site of the previous abscess may be seen.

the patient returned to the ward in poor condition. He remained comatose and the following day had a convulsion. Following this his temperature mounted to 104°F and he expired on the second postoperative day.

At autopsy the left lung was clear as were the right middle and lower lobes. The right upper lobe was heavy, atelectatic, showed multiple abscesses with surrounding pneumonitis and bronchiectasis. The brain was somewhat edematous but exhibited no gross or microscopic lesions. Our opinion was that the patient died as the result of air embolus.

Comment—We have reported one case which is of considerable interest because it occurred spontaneously without known cause. It had an insidious onset with few symptoms, the patient remaining ambulatory and refusing hospitalization. Early in the course the sputum was foul but the usual symptoms of putrid lung abscess were not present until later. This case therefore presents a picture which cannot be readily classified in any grouping that might be made. While the case was mild and insidious in onset, it gradually progressed to the stage where hemorrhage occurred and multiple abscesses were formed. This is always a serious complication. Lobectomy was finally considered and the pleural cavity was entered but on account of serious adhesions this plan was given up. Here was a patient who undoubtedly could have been saved by early operation but the condition became chronic and inoperable and the patient finally expired.

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THE EARLY TREATMENT OF WOUNDS OF THE FACE

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In discussing wounds of the face with you this morning I must tell you that I am drawing largely on my experience in the last war and the impression that these wounds as a class did not receive in the beginning the proper early attention that they deserved. This was due largely to the general impression that such wounds were always grossly infected and that it was therefore necessary to leave them open and treat the infection for varying and sometimes long periods of time before the tissues were replaced to even approximately the normal position. This led to long continued suppuration with its attendant evils unnecessary loss of tissue muscle sclerosis fibrosis and contraction with permanent loss of the pliability of the tissues even when they had not been completely destroyed. All of this greatly contributed to the almost insurmountable difficulties that had to be met in the effort at final reconstruction and was largely responsible for the great deformity and permanent loss of function that these patients had to endure. War wounds of the face are of all degrees of complexity and their exact life is not often seen in civil practice although the same ideal of early systematic and thorough treatment with the desired final result ever before us obtains in both.

We presume a familiarity with the anatomy of the face with its partly movable but mostly immovable underlying structure of bone its cavities and the covering mobile soft tissues. In addition we must remember it as having within its confines the specialized mechanisms of sight smell hearing speech and taste housing the normal entrance for the aliment and the breath of the body it contains within it numerous secretory

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structures whose important products are not normally noticed but which become obvious when escaping constantly from their normal bounds. It is largely the site of the highly specialized mimetic processes and mirrors the ever changing moods and vapors of the mind. As we go up in the scale of mammalian life the mimetic muscles become more and more differentiated and it is common knowledge that in many abnormal mental and emotional states the expressiveness of the face is lost. This close association of the face and the mind has important implications and I have never seen a serious disfiguring wound of this area that was not accompanied by serious psychic injury as well.

The foresight and the care given to the organization for the treatment of these wounds in the present war have taken all of the above factors into consideration with the result it is to be hoped that the earliest as well as the succeeding steps will be seriously considered to have a most important bearing upon the final results. No half way measures can be condoned in the beginning with the thought that because future operations will be needed they can be corrected later. The principles of wound treatment in general are applicable to this region as well with certain modifications but it is certain that the earlier the wound is surgically cleansed and the tissues replaced and immobilized the better will be the result with fewer complications and with a shorter period of disability.

IMMEDIATE TREATMENT

The immediate treatment will be concerned with measures to save life. Suffocation is often a pressing danger and an air way must be promptly and surely established by the elimination of obstruction. Foreign bodies must be removed from the mouth and throat. In wounds of the lower part of the face (Fig 436 a) with destruction of the bony supports the tongue and floor of the mouth must be lifted up and held there. A suture or a safety pin passed vertically through the tongue and fixed to a bandage or to a top button of the uniform has been suggested. A metal or rubber airway may be passed back to the glottis or in more desperate situations it may be necessary to pass a trocar through the cricothyroid membrane into the trachea. Tracheotomy should be done only as a last resort. It

is not a simple operation in these trying conditions and even when conditions are ideal it can be difficult in a struggling bleeding patient and it needs watching especially in the early postoperative stage. In the case of unconscious patients special attention must be given to fixation of the airway apparatus and the assurance of a posture that will prevent obstruction by pressure or by the accumulation of wound fluids blood or vomitus.

Bleeding must be controlled by direct pressure by a forceps left in position or by tamponade with a sterile dressing and compress left in place and held in position by a rubber band or a bandage. A safety pin may be passed around a vessel through soft tissue or a straight pin may be passed on each side and ligatures wrapped around their ends. Direct ligation of a point in the wound may be possible and is better than ligation in continuity which is often equivalent to mutilation adding to tissue loss and infection.

When bleeding has been controlled chemotherapy should be used locally the available drug being carefully sprinkled into the depths and crevices of the wound over the exposed bone and tissue and on the skin. The tissues should then be brought into as near the normal position as possible and fixed with sterile gauze dressings and bandages. Pieling of the wound with gauze must accomplish its purpose and do no more. Too tight picking is injurious causes necrosis obstructs breathing and leads to secondary hemorrhage. The wound should not be pieled with any old rag instances of fierce infection have followed the use of a handkerchief or portion of clothing for this purpose. The application of an adequate bandage must be stressed for it must fix and hold the dressing and the parts in position. A strip of adhesive may not suffice. One may have cause to deplore the present tendency to neglect instruction in the art of bandaging. Morphine must be given to control pain and should be used in doses large enough to be effective. A robust young man needs a larger dose than the usual patient—perhaps $\frac{1}{2}$ grain is the minimum dosage in these cases. Gas infections do not usually occur in this region but they can occur and should be looked for and treated early. Antitetanic serum should not be given if toxoid has been used.

DEFINITIVE TREATMENT

The definitive treatment should be started within twenty-four hours. This is important. It is to be hoped the patient can be under the supervision of a skilled surgeon and dental surgeon. They together analyze the wound and determine the extent and nature of injury. The dressing is removed and the wound is examined minutely under anesthesia. Permanent hemostasis is established after the wound has been opened to its depths. The recesses and pockets are cleansed with meticulous care. All foreign bodies are removed after they have been located by x-ray examination which also determines the nature and extent of injury to the bones. Inblown splinters and fragments of bone and teeth are removed and detritus around them wiped away. Loosened teeth are taken from fracture lines and depressed bones elevated. The wound should be cleansed by irrigation with normal saline and by careful scrubbing or wiping with pledgets of cotton. Clots are removed and subcutaneous and submucous extravasations of blood are wiped away.

Completely devitalized soft tissue is excised but this should be done with caution because in this area the usual rules of wide excision do not apply. The object should always be to save any and every tag of tissue that has a chance to live. Strips of skin and mucous membrane having any attachment may prove later to be invaluable. They should be tacked down as near their normal position as possible and used to cover denuded areas of bone or bone ends or raw areas in soft tissue.

Wounds of the cheek (Fig 436 *b*) may expose but not completely destroy the facial nerve. It should be guarded. The divided parotid duct if fixed to a nearby tag of lining oral mucous membrane may give little trouble later.

If the orbit has been damaged (Fig 436 *c*) it should be carefully examined. A destroyed eyeball and intraorbital foreign bodies are removed and nonviable soft tissue is excised. Search of the orbital roof should be made. If it is penetrated and brain substance is escaping an urgent problem is presented. The urgency of the neurosurgical problem may delay more complete treatment of the face but careful cleansing of the orbit and suture of the lids are advised. If the floor of the orbit is lowered and the orbital rim displaced they should be lifted back into position and held there by direct suture if necessary.



Fig. 436—*a e* Wounds of the face seen in the surgical service of A. R. C. Military Hospital No. 1 Nully, and A. R. C. Military Hospital No. 11 Jully, France 1917-1918

The nasal fossae should be examined and cleansed bones replaced by pushing or pulling them back to normal position and nasal mucosa conserved by suturing it to nearby skin. Here as elsewhere any piece of bone that has an attachment is allowed to remain only completely detached pieces being justifiably removed. The nasal sinuses whose walls are damaged are explored and cleansed of all debris and the malar bone and the zygoma if displaced are lifted into position and fixed. The damaged sinuses are drained into the mouth or nose.

In injuries to the lower half of the face where the oral cavity is opened (Fig 436 *d*) there are greater possibilities of infection. While all of the rules for careful cleansing and conservation and fixation of tissue still apply the question of drainage is of special importance. All wounds that open the floor of the mouth should have dependent drainage. The tongue is sutured and the floor of the mouth repaired. Strips of the lining mucosa are sutured to the nearby skin again with no needless sacrifice. As the tissues are replaced and held they should be brought together without tension. If the approximation of the soft tissue causes the displacement or overlapping of fractured bones it should not be done. Care in joining the divided eyelids or lips at this time will save trouble later. Sometimes the divided lower lip can be repaired so as to contain the oral secretions but not if it displaces or shortens the fractured lower jaw (Fig 436 *e*).

Local and general chemotherapy should again be instituted and finally reduction and immobilization of the fractured maxilla and mandible must be done by whatever method the dental surgeon chooses as appropriate for the situation. It should be the purpose to immobilize the bones in good functional position not necessarily to get the fractured ends together but to restore normal occlusion of remaining fragments and conserve the function of the temporomandibular joint prevent infection of bone and permit the taking of nourishment. The question of feeding is important. A rich liquid diet high in vitamins is given through a tube with cleansing of the wound after each meal.

All treatment must be carried out under strict asepsis. Even if infection is probable in these destructive wounds which open the mouth, nose and sinuses the possibility of superimposed exogenous infection must be taken into account and every precaution taken to prevent its occurrence. The use of bulky dress

ings which become saturated with wound secretions and which prevent the necessarily frequent inspection of the wound is not advisable. Complications such as infection, cellulitis and abscesses may occur; they should be quickly recognized and promptly treated.

The threat of bone infection must be considered from the beginning. Much can be done to prevent it by careful early cleansing, chemotherapy and reduction and immobilization of fragments. If it occurs it should be treated conservatively and no vigorous operative methods employed. More bone will be saved usually if a sequestrum is allowed to form.

THE TECHNIC OF TOTAL GASTRECTOMY WITH PARTICULAR REFERENCE TO THE USE OF LOCAL ANESTHESIA*

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and

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IN the last few years the literature has contained an increasing number of reports of cases in which total gastrectomy has been performed for extensive lesions of the stomach. Twelve such operations have been performed on the University of California General Surgical Service by a technic similar in most cases to that described by Allen. Usually the disease for which total gastrectomy is indicated is far advanced and often the physical condition of the patient is very poor so that the technic employed must permit the use of local anesthesia. This was true in seven of our cases of which the report below is an example.

CASE REPORT

L K, a man fifty four years old, had suffered for four months with epigastric discomfort accompanied by vomiting, hematemesis and tarry stools. For many years he had had chronic pulmonary tuberculosis for which a left phrenicectomy had been performed. The patient appeared to be very ill. He was pale, emaciated and dyspneic upon the slightest exertion. He coughed frequently and produced a small amount of sputum with each paroxysm. No abdominal masses were felt and no evidence of distant metastases could be found. X-ray examination of the stomach following a barium meal showed evidence of an infiltrating polypoid lesion in

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involving the cardia and a large part of the remainder of the stomach (Fig 437A). The hemoglobin was 60 per cent and the red blood cell count 3.4 million; urinalysis was negative. The serum albumin



Fig 437—A. Barium meal radiograph taken after a barium meal showing evidence of an extensive lesion of the stomach. B. The esophageal anastomosis seen 1 month after total gastrectomy. C. The esophageal anastomosis ten months after total gastrectomy.

was 3.6 gm and the globulin was 3.4 gm per 100 cc of blood. The test for plasma chlorides showed 528 mg per 100 cc of blood. The intravenous hippuric acid test yielded 1.7 gm in 1 hour.

TECHNIC OF TOTAL GASTRECTOMY

The patient was prepared for operation over a period of days and during this time two transfusions of citrated whole (500 cc each) were given. Two grains of sodium phenobarbital and $\frac{1}{6}$ grain of morphine sulfate were administered just prior to operation. Local anesthesia was employed. The abdomen was approached through an upper midline incision. A large ulcer was found extending upward from the prepyloric region to the greater curvature to involve the entire upper two thirds of the stomach including the cardia. Total gastrectomy was performed. A retrocolic anastomosis was effected between the jejunum and the esophagus and an entero-entero anastomosis between the proximal and distal jejunal loops was performed. The blood pressure was 95 systolic and 70 diastolic at the beginning of the operation; it did not drop below this figure during the procedure. The pulse rate ranged between 108 and 130 and was of good quality throughout the operation which lasted six hours. The entire procedure was accomplished under local anesthesia.

Convalescence was complicated by considerable respiratory insufficiency but otherwise proceeded satisfactorily. At first the patient required frequent feedings of prepared foods but soon was able to take three regular meals daily. For some time his nutrition was fairly well maintained although he was somewhat anemic (12 per cent hemoglobin). Recently his pulmonary tuberculosis became active and he lost weight. At present he is alive without signs of recurrence twenty-two months after total gastrectomy; he is confined to bed with active advanced pulmonary tuberculosis. His postoperative roentgenograms are shown in Figure 437.

TECHNIC

The use of local anesthesia for operation on the upper abdomen and the technic of total gastrectomy have been described separately by several authors but the use of local anesthesia in connection with total gastrectomy appears to justify its description here. Total gastrectomy under local anesthesia is a long and laborious procedure demanding the most of a surgeon's time, patience and skill. He must anticipate accurately the operative movement and make sure that the anesthetic precedes it. Each manipulation must be gentle and deliberate.

The patient is prepared by establishing adequate hydration and proper electrolyte balance and hypoproteinemia and vitamin deficiencies are treated. The stomach is thoroughly cleansed mechanically by means of aspiration lavage. Pre-

ative medication consists of an appropriate dose of morphine and a barbiturate.

Novocain in 0.75 or 1 per cent solution containing 7 or 3 drops of adrenalin to the ounce is used. It is injected by means of a simple Luer syringe with precautions to prevent intravascular injection. The epigastrium is anesthetized by use of a combination of regional nerve and field blocks. The adminis-

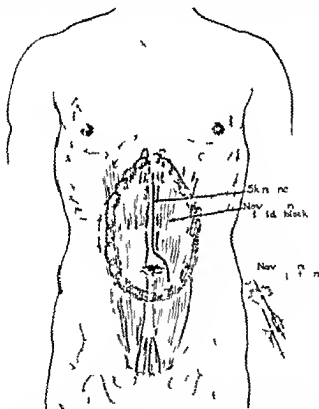


Fig. 438.—Drawing showing the field blocked by local anesthesia and the skin incision employed for operations upon the upper abdomen.

tration is begun by infiltrating the skin with the novocain-adrenalin solution, producing intracutaneous wheals outlining the field as indicated in Figure 438. The nerves entering the field are blocked by injection through the skin wheals of about 2 cc of the anesthetic mixture at intervals of 1 cm. beneath the fascial layers along the costal margins, the lateral borders of the rectus muscles about the umbilical region and across the lower margin of the field.

An incision is made in the skin from the highest point in the epigastrium to a point below and to the left of the umbilicus (Fig 438) The subcutaneous fat fascia and peritoneum likewise are divided in the midline beginning at the lower tip of the ensiform process The lower end of the incision extends for a short distance into the left rectus sheath Before it is incised the peritoneum is infiltrated directly with the anesthetic solution After the incision in the peritoneum is complete that

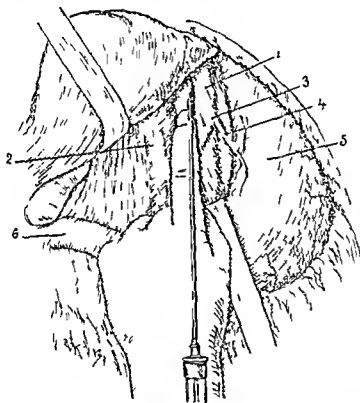


Fig 439—The site of introduction of the needle between the aorta and vena cava at the level of the body of the first lumbar vertebra for splanchnic anesthesia 1 Aorta 2 vena cava 3 trunk of the coeliac artery 4 left gastric artery 5 stomach 6 duodenum (Finsterer)

structure is further anesthetized for a distance of 3 or 4 inches on both sides of the incision The administration of the local anesthetic and all other operative manipulations within the abdomen must be done deliberately and with a very delicate touch The method for anterior splanchnic block devised by Braun and popularized by Finsterer and others is employed and additional anesthesia is obtained by infiltrating the inferior surface of the diaphragm and the attachments including adhesions of

all other structures before they are handled. Before any structure is placed under tension or is divided it is infiltrated with a few cubic centimeters of novocain adrenalin solution.

The inferior surface of the right lobe of the liver near its anterior margin is retracted upward gently and a needle is introduced through the posterior parietal peritoneum in the space between the aorta and the inferior vena cava into the retroperitoneal tissues until it impinges upon the body of the first lumbar

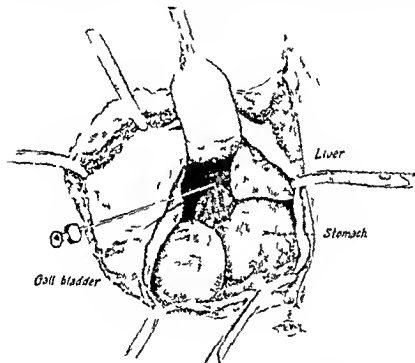


Fig. 440 - The operative exposure of the upper abdomen for splanchnic anesthesia (Braun: Local Anesthesia, 1st & 2nd ed.)

vertebra (Figs. 439 and 440). The needle is withdrawn slightly ($\frac{1}{8}$ inch or less) and after taking precautions to avoid intravascular injection the splanchnic region is infiltrated with from 40 to 75 cc of the novocain adrenalin solution. The lesser omentum is then injected up to the cardiac end of the lesser curvature of the stomach. At this time the stomach may be examined completely for determination of the extent of the lesion and its operability. It is particularly important that the lower end of the esophagus be examined carefully before the

resection is begun. If total gastrectomy is indicated the available portions of the inferior surface of the diaphragm are infiltrated with anesthetic solution to the esophageal hiatus. The ligamentous attachment to the left lobe of the liver also is infiltrated with the solution and then divided and the lobe is retracted to the right as described by Turner. The region about the duodenum must be blocked thoroughly to prevent retching or vomiting when this structure is lifted.

Because the effect of the local anesthetic lasts no longer than from one and a half to two hours it is necessary to infiltrate the splanchnic and other intra abdominal areas that require anesthesia at least twice and occasionally three or four times before the operation has been completed. Also the abdominal wall must be re-infiltrated with anesthesia at appropriate intervals. The surgeon should not wait until the anesthesia has worn off. The patient must not experience the slightest discomfort or pain which would cause straining thereby forcing the abdominal contents into the incision and necessitating abandonment of the operation under local anesthesia.

Usually the distal end of the stomach is detached first by dividing the duodenum just distal to the pylorus. The duodenal stump is inverted with a Parker Kerr type of suture and this closure is reinforced with interrupted sutures of fine silk placed with very small needles and tied just firmly enough to appose the tissues accurately. The stomach and its attachments including the entire greater omentum and most of the lesser omentum are removed. The blood vessels are ligated individually with fine silk as they are encountered. Splenectomy may be performed if it appears that this will facilitate the removal of the growth or increase the possibility of its complete removal. To prevent possible retching and vomiting the region of the esophagocardiac junction must be anesthetized and the branches of the vagi identified and sectioned before traction is applied to the stomach.

In some cases it seems desirable to leave the stomach attached to the esophagus as traction upon it assists in the placement of the posterior line of sutures for the esophagojejunal anastomosis. In other cases it is easier to divide the esophagus between large right angle clamps (Wertheim type) before beginning the

anastomosis. All incisions in the intestine are made with the electrosurgical unit.

Usually the esophagojejunal anastomosis is made by the method described by Allen. The base of the transverse mesocolon should be infiltrated with local anesthetic before traction is made upon it. The proximal loop of jejunum is brought up to the esophageal hiatus of the diaphragm. It must rest in its new situation without the slightest tension. We have used both antecolic and retrocolic anastomoses and both are satisfactory; however, if the latter is employed, the ligament of Treitz must be incised and only the distal jejunal loop be permitted to emerge from and be sutured to the inferior surface of the transverse mesocolon (described by Lacey). The lower end of the esophagus is placed adjacent to the side of the loop of jejunum at the site of the proposed anastomosis. Several interrupted silk sutures are used to anchor the jejunum behind the esophageal hiatus. A posterior line of interrupted silk sutures is then placed between the posterior wall of the esophagus and the jejunum. An incision is made in the wall of the jejunum. The clamp is removed from the lower end of the esophagus or, if the stomach has been left for traction, the esophagus is divided and the stomach is removed. To prevent soiling of the operative field, it may be useful to have continuous suction applied to an indwelling catheter in the esophagus (as suggested by Allen) during the period in which the esophagus is opened. A fine (No. 00 or 000) continuous suture is placed around the interior of the esophagojejunal stoma. The anterior suture line between the esophagus and jejunum is then reinforced with a layer of single interrupted sutures of fine silk. Several interrupted silk sutures are used to anchor the jejunum to the diaphragm in front of the anastomosis. This completes the esophagojejunal anastomosis. There must be no tension on the jejunal loop leading to this anastomosis. A lateral entero-anastomosis is made between the proximal and distal jejunal segments.

Throughout the process of incising and anastomosing the intestines, meticulous care is exercised to prevent or at least to minimize contamination of the peritoneal cavity. Skillful use of aspiration and of appropriately placed laparotomy pads, the strict observance of the technic for handling and discarding contaminated instruments and materials, the use of the electro-

scalpel to make the incision into the intestine and the replacing of sterile gloves and drapes at suitable times all contribute substantially to the prevention of soiling of the peritoneal cavity during the operation. If a retrocolic anastomosis has been performed, the opening in the transverse mesocolon must be closed and attached to the efferent jejunal loop. The abdominal wall may then be closed.

POSTOPERATIVE CARE

After operation the patient is kept flat in bed for from five to ten days. He should be moved from side to side at frequent intervals but the semireclining and upright positions in bed usually are avoided in the early postoperative period to lessen possible strain on the anastomosis.

If an indwelling tube is to be used for feeding, it may be passed well into the distal segment of the jejunum during the operation. It should be small and very flexible. Recently our practice has been to remove the tube from the esophagus at the end of the operation and to administer fluids and proteins entirely by parenteral methods. The patient is allowed to swallow very small sips of water or other clear fluid beginning about the second postoperative day.

If convalescence is progressing well frequent small feedings with thin liquid food are begun about the seventh day. If liquids are tolerated well from five to eight meals daily—consisting of small amounts of soft foods—may be taken very slowly. After several weeks or months a few patients are able to eat three regular meals daily and maintain a satisfactory state of nutrition. Others must eat from six to eight small meals of soft and liquid foods. If the patient has difficulty in swallowing a small amount of thin barium mixture will demonstrate the degree of narrowing at the esophagojejunal stoma (Fig 441). In the early postoperative period this may result from edema associated with nutritional deficiency or with inflammatory reaction at the stoma. In such patients the stoma probably will open after a few days and parenteral protein and vitamin therapy should be given. If the narrowing at the lower end of the esophagus is caused by spasm it may respond to drugs containing atropine and this response may be visualized during fluoroscopy (Fig 441 C D). Obstruction of the esophagojejunal stoma that comes



Fig 4H

on several weeks or months after operation may be due to fibrous contractures at the site of anastomosis (Fig 441 E) In such cases instrumentation may be required to relieve the obstruction

SUMMARY

Patients for whom total gastrectomy is performed usually have extensive lesions of the stomach and often are very poor risks for the operation In such cases it may be desirable to use local anesthesia In a group of twelve cases in which total gastrectomy was performed the entire procedure was accomplished by the use of a local anesthetic in seven The technic for total gastrectomy under local anesthesia is described

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Fig 441—M L A Roentgenogram taken after a barium meal showing the extensive carcinoma of the stomach B The esophagojejunal anastomosis three months after operation The esophagus emptied freely at this time C The esophagojejunal anastomosis six and one half months after operation The patient complained of dysphagia The esophagojejunal region was narrowed and the esophagus failed to empty properly This probably was due to spasm at the distal end of the esophagus or at the stoma D Roentgenogram six and one half months after total gastrectomy The administration of atropine permitted the esophagus to empty promptly Compare with C E Fourteen months after total gastrectomy The patient's dysphagia returned and could not be relieved by drugs X ray films taken after the administration of barium mixture revealed rigid narrowing of the esophagojejunal anastomosis probably the result of cicatrization

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THE SURGICAL CLINICS of NORTH AMERICA

Philadelphia Number

SYMPOSIUM ON WAR SURGERY

INTRODUCTION

For making possible at this time the publication of a symposium on War Surgery by men who have had unusual access to such clinical material which needs far more than priority to obtain the publishers of this volume place the American Surgical profession under deep obligation

Of the contributions from the military forces the three naval hospitals compose only 58 per cent against 42 per cent from the one military unit, speaking numerically, but it would be difficult to evaluate them in this way relatively

These papers are a real contribution to American Surgery both civil and military. They are based upon unusual clinical opportunities which the war experience has made possible for these especially trained authors and the problems they discuss are all vital not only at the present time but for the future

Captain Shaar has in a clear and definite way presented the Care of the Injured in Combat Zone from the naval officers point of view which military officers now realize is very largely determined by the terrain environment and equipment. Other problems such as the compound fractures of the long bones are not only military but very important for the civil industrial surgeon. War burns either because of their size or depth present problems which are not constant in every civilian burn but the principles involved are the same

No one who has seen continuous caudal anesthesia employed in the production of painless childbirth will deny the possibilities of this new contribution to both obstetrics and surgery

Finally but not the least by any means the demonstration of

Colonel Spurling of a new suture material in the form of Tantalum Wire and Foil should be seen following the reading of this clear presentation in order to fully appreciate the value of this contribution to surgical technic

WALTER ESTELL LEE

THE USE OF TANTALUM WIRE AND FOIL IN THE REPAIR OF PERIPHERAL NERVES*

LT COLONEL R. GLEN SPURLING
Medical Corps Army of the United States

THE history of metal appliances in surgery has been reviewed recently by Venable and Stuck.¹ Enough experimental and clinical evidence has been accumulated to say that now after nearly 400 years of searching there are metals (or alloys) available which when buried in human tissues are practically inert.

Two metals, vitallium and tantalum, appear to fulfill all requirements for inertness when subjected to the complicated metabolic activities of the human body. Vitallium is a hard alloy of cobalt, chrome and molybdenum and must be cast as it can not be worked cold. Tantalum is a basic element, strong, tough and malleable. It can be drawn into a wire as fine as human hair with good tensile strength and it can be rolled into a foil so thin that nerves and tendons at the wrist may be wrapped in it without producing deformity.

The reaction of nervous tissue to tantalum implants has been investigated by Pudenz,² Pudenz and Odom,³ and others. The tissues in the immediate vicinity of the metal show little or no evidence of foreign body reactions, a minimum of leukocytic infiltration and gliosis and no giant cell formation.

The usual method of end to end repair of large nerves with only a series of sutures in the perineurium is open to certain criticisms. Correct apposition at the periphery of the union can probably be maintained but the centrally placed tubular structures may separate, particularly if there is any tension upon the loose tissue of the perineurium. Also, if there is even a small amount of bleeding from either the proximal or distal stumps, a blood clot will form within the perineurial sleeve which separates further and forms an additional barrier to the growth of the central tubes. A sling (or traction) stitch placed

*From the Neurosurgical Section, Walter Reed General Hospital, Washington, D. C.

through the center of the upper and lower trunks and tied with just enough tension so that the tubular structures meet appears to be an answer to these criticisms. The chief objection to such a stitch in the past has been the inflammatory reaction occurring around the suture material—either black silk or catgut.

The replacement of a carefully made nerve anastomosis into a bed of scar tissue has generally been conceded to be undesirable. Many materials (fat pads, fascial sheets, preserved membranes and excised segments of arteries and veins) have been tried in an effort to eliminate or diminish the extrinsic scar. Most of them have been abandoned because it has been found that the resulting fibrosis was seldom diminished and was often increased by the would be protective substance. Yet if the carefully repaired nerve is replaced into a scarred operative field with no protection it will surely promptly become adherent. Perhaps the extrinsic scar is not important insofar as infiltration of fibroblasts into the suture line is concerned but certainly the fixation that accompanies it is undesirable.

These considerations prompted the present clinical study of the use of fine wire of tantalum for suturing and a cuff of tantalum foil around the area of anastomosis.

The first patient to be operated upon with this technique (Sept. 1, 1947) had had the ulnar nerve severed 3 inches above the elbow. He had been wounded by machine gun fire in the South Pacific and had been twice operated upon before arriving in America. The ulnar paralysis was complete and a painful neuroma at the site of injury was evident. The nerve was sutured after excision of the neuroma and transplantation of the distal end of the nerve beneath the pronator muscles. The progress in this case was such that I have been encouraged to operate in forty five additional cases using the same technique. A separate report of the early results in these cases will be made presently but it may be said at this time that evidence of regeneration has occurred with regularity at a rate closely paralleling the experimental results of delayed suture reported by Young⁶ and others.⁷

SURGICAL TECHNIC

No discussion of technical details of peripheral nerve surgery would be complete without first re-emphasizing the importance

of two cardinal principles (1) freedom from tension (2) perfect hemostasis

When large gaps are to be overcome tension is by far the most difficult problem. Yet to compromise with this principle means inevitable failure. The difficulties attending end to end suture where there has been loss of substance have prompted many surgeons to attempt both autogenous and homogenous nerve grafting and various splicing operations. It is not the purpose of this report to discuss these makeshift procedures for direct anastomosis. No doubt there is some merit in the more recently described⁷ grafting techniques but all observers are fully agreed that end to end suture is always preferable. It can be accomplished in many cases only by extensive dissection of the proximal and distal ends of the severed nerve and by positioning the joints of the extremity to shorten the course of the nerve. In most major nerve trunks, gaps of from 3 to 4 inches can be overcome by correct dissection and positioning.

It has often been said that extensive dissection of a nerve trunk destroys too much of the blood supply for satisfactory regeneration to occur. This assumption is probably incorrect as I have on several occasions stripped 18 inches of the central end of a major nerve trunk with good functional recovery. The longitudinal blood supply is probably the most important and if this is undamaged by the dissection no ischemic degeneration should occur.

When motor branches must be sacrificed in order that tension may be relieved due consideration should be given to the handicap produced and the possibility of combating it at a later date by appropriate tendon transplantations.

After the greatest mobilization by dissection has been made the joints of the extremity should be placed in the optimum position to shorten the course of the nerve. The joints should be flexed only enough to accomplish this objective.

Careful hemostasis is specially important in peripheral nerve surgery. A wet field with the inevitable swelling that accompanies it is incompatible with consistently good results. It should be unnecessary to say that a tourniquet is seldom necessary or justifiable in operations upon peripheral nerves unless there is an associated lesion of one of the major blood vessels.

After trimming the central stump until normal appearing

nerve bundles are seen and the distal stump until well formed bundles of Schwann cell tubes are evident brisk bleeding from the stumps may occur. This is best controlled by placing and holding in place with gentle pressure a thin strip of muscle over each cut end. After three or four minutes the muscle implant can be gently removed with a stream of normal saline without again opening the bleeding points.

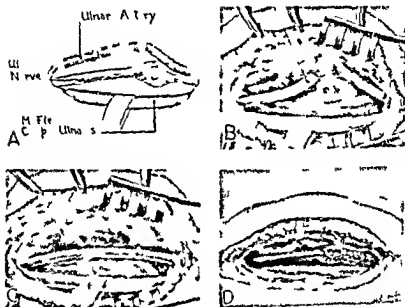


Fig. 442—Drawing illustrating the steps in the repair of an ulnar nerve in the lower third of the forearm. A The ulnar nerve with a large neuroma at the site of the previous operative repair. B The neuroma has been resected and the sling stitch placed. Note orientation sutures of black silk. C The repair with interrupted sutures of tantalum has been completed. D The cuff of tantalum foil has been placed.

The through and through sling stitch of $\frac{1}{1000}$ tantalum wire is then applied care being taken to avoid injury to one of the larger blood vessels in the perineurium (Figs 442 to 446). When the sling stitch is tied great care must be exercised so that the cut surfaces of the proximal and distal stumps just touch each other. Too much tension on this stitch causes wrinkling of the tubes; too little leaves an undesirable dead space. After this stitch is properly placed and tied a series of fine

interrupted sutures of $\frac{3}{1000}$ tantalum wire are placed in the perineurium. The purpose of these sutures is to form a sleeve around the point of union. Recently I have used a continuous suture of fine tantalum wire in the perineurium with good results.

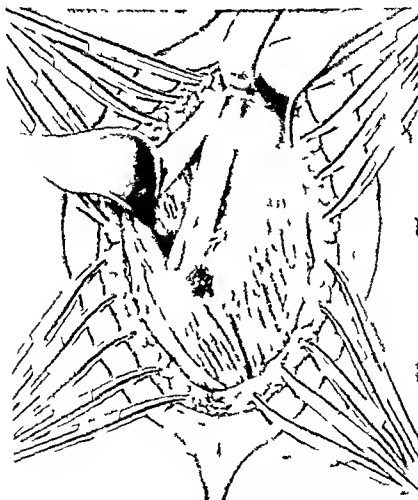


Fig. 443—Severance of the outer half of the sciatic nerve by bayonet. Note the large neuroma formed just above the scar.

In making an end to end suture it is highly desirable that no twisting of the proximal or distal trunks should occur. An orientation suture of black silk in the perineurium above and below the lesion is helpful in avoiding rotation after the ends are excised and the sling stitch placed (Fig. 442).

After the anastomosis is completed and the operative field

thoroughly dried a cuff of tantalum foil is wrapped snugly around the nerve and held in place with circular ties of fine tantalum wire (Figs 442-446). The length of the foil cuff is determined by the extent of the scar into which the nerve must be placed. I have used a 4 inch cuff on several occasions but usually no more than 2 inches will be required.

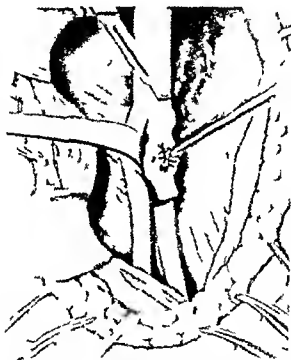


Fig. 444.—The nerve and scar are excised. Note that the medial half of the nerve is intact.

Closure is made by an anatomical repair of the wound with interrupted sutures of black silk.

The proper restraining cast or posterior shell is then applied to maintain the joints in correct position. Immobilization is complete for two weeks after which physical therapy is started and gradual passive extension of all joints is accomplished by the sixth postoperative week.

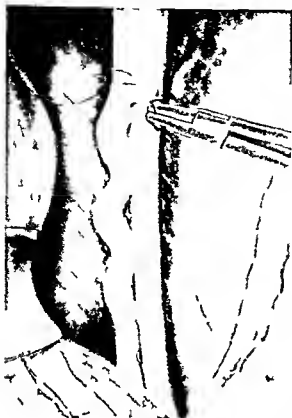


Fig 445—An end to end suture of the outer half of the nerve is accomplished after extensive dissection of the proximal and distal ends and 90 degree flexion of the knee



Fig 446—A partial tantalum foil cuff is placed around the outer half of the nerve and held in position by two sutures of fine tantalum wire through the perineurium.

TISSUE REACTION TO TANTALUM FOIL

An opportunity to re operate upon a patient who had had a tantalum foil cuff around the upper trunk of the brachial plexus for four and one half months soon presented itself. The patient had on April 18, 1942 sustained a knife wound in the supraclavicular fossa resulting in immediate loss of all motor and sensory function of the fifth and sixth cervical nerve roots.

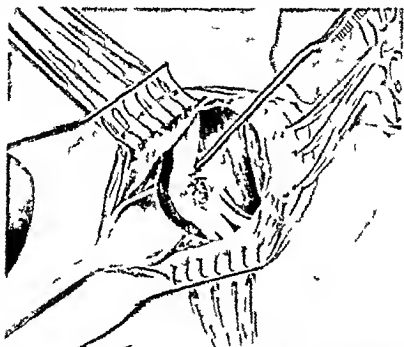


Fig 447—Dissection of the upper trunk of the brachial plexus. Note the fifth and sixth cervical nerve roots above the scar and the primary divisions of the trunk together with the suprascapular nerve below the scar.

An early attempt was made elsewhere to repair the plexus but by the end of the eighth month there was no sign of regeneration. Re exploration on December 22, 1942 showed complete destruction of the upper trunk of the plexus with characteristic neuroma formation on the central stump (Fig 447). The whole trunk was excised (Fig 448). Then the fifth and sixth roots were brought together to resemble a trunk and the two primary divisions and the suprascapular nerve were sutured into it. A

small cuff of tantalum foil was wrapped loosely around the junction

Roentgenograms taken at regular intervals during the next four and one half months showed a definite change in the size and position of the cuff. Because of these changes re exploration of the plexus was carried out.

The usual dense scar was found enveloping the neurovascular bundle but dissection of the plexus at the site of the former anastomosis was accomplished without difficulty. The tantalum foil was fragmented and was picked out of the wound in small pieces. On either side of where the foil cuff had been two re



Fig 448—Three stages in the repair of the plexus. *A* A new trunk was reconstructed by uniting the fifth and sixth cervical nerve roots. *B* The two divisions and the suprascapular nerve were sutured end to end into the reconstructed trunk. *C* The trunk was wrapped with tantalum foil.

markably smooth glistening surfaces were observed. Immediately above and below the cuff the nerve was adherent. The site of the anastomosis could not be demonstrated (Fig 449).

Tissue for histological study was taken from three zones: (1) in the dense scar tissue in the vicinity of the former operation but not in contact with the tantalum foil; (2) in the scar immediately adjacent to the foil cuff; (3) from the nerve itself in contact with the inner surface of the foil cuff.

I am indebted to Lt Col Carl Lind Jr, MC USA, Chief of the Laboratory Service of the Walter Reed General Hospital, for studying the tissue and for interpreting the histological data reported herewith.

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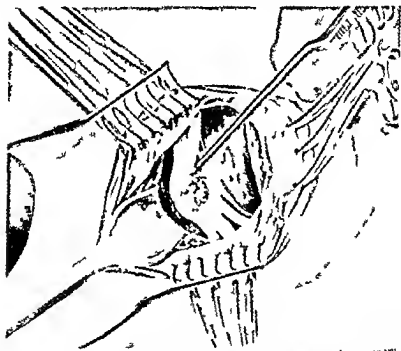


Fig. 447—Drawing of operative field showing dense scar in the upper trunk of the brachial plexus. Note the fifth and sixth cervical nerve roots above the scar and the primary divisions of the trunk together with the supraclavicular nerve below the scar.

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Specimen 1 (Fig 450) The section has no anatomically defined edge. It is formed of dense strands of mainly collagenous connective tissue in which several foci are undergoing hyalinization bordered by fibroblasts. There are moderate numbers of scattered dilated vascular channels rimmed by small number of inactive mononuclear cells generally in transition to fibroblasts. There are no eosinophils or neutrophils. There is a proliferative connective tissue reaction with mild chronic inflammation (Control biopsy showing the usual response after operation.)

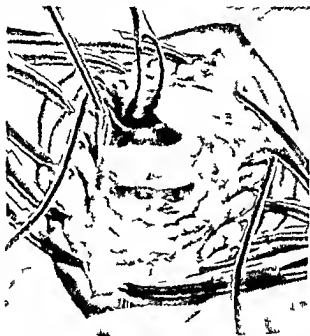


Fig 449—Drawing showing condition of the tissues in the region of the tantalum foil cuff four and a half months after operation. Note smooth gliding surfaces on either side of the foil and the fragmentation of the foil.

Specimen 2 (Fig 451) Low power view shows a very smooth border (against the tantalum foil). Extending outward from this is a narrow (60–150 $m\mu$) band of avascular delicate connective tissue showing no inflammation, then a thin zone (60–200 $m\mu$) of rather delicate elastic fibers bordered towards the foil by a 10- $m\mu$ condensed and continuous band of elastic tissue resembling a lamina and an outermost zone of mild collagenous fibrosis. There is a mild chronic inflammatory reaction in the elastic zone with dilated vessels.



Fig. 450—Hematoxylin-eosin. Shows usual postoperative fibrosis.



Fig. 451—Hematoxylin-eosin. View across border in contact with tantalum foil. Shows delicate cytoplasmic border composed of loose, relatively acellular, nonvascular connective tissue. No inflammatory reaction.

High power examination reveals that in the region where the tissues would be in contact with the tantalum foil there is a narrow (5 to 10 $m\mu$) band of denser eosinophilic tissue. The relatively scanty nuclei of the innermost zone are increased here and maintain their oval or spindle shapes and lie parallel to the edge. There is some resemblance to condensation at a serous surface. With the Masson connective tissue stain cytoplasm lines the surface and some of the nuclei are directly on the surface. The granulation

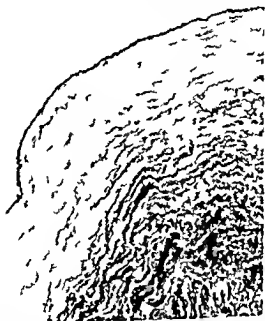


Fig. 45—Masson connective tissue stain. View across nerve in contact with tantalum foil. This shows delicate cytoplasmic layer abutting the region of the foil and outside a dense connective tissue layer surrounding the nerve.

is seen to be cytoplasmic. Short delicate fibrils taking the nuclear stain pass through the cytoplasm.

Specimen 3 (Fig. 452) This shows the membrane over a nerve. From the region of the foil there extends for 250 $m\mu$ a layer of delicate connective tissue as in specimens 2 and 3. Within this is regenerating nerve tissue showing slight chronic inflammation. There is mild deep fibrosis with collagenous tissue formation and some old blood pigment.

Discussion—In contrast to the usual marked postoperative fibrosis the specimens abutting the tantalum foil show interesting variations. First there is a layer of delicate connective tissue

against the foil which shows no particular inflammation or fibrosis. There appears to be no reaction to the foil. Second, there is less inflammation and fibrosis in the tissues as a whole than usual.

Of considerable anatomical interest is the similarity in structure to vessel or cavity wall. This suggests that mechanical forces and factors play a major part in determining the layering of connective tissues in this case parallel to the inert tantalum.

OTHER ADVANTAGES OF TANTALUM SUTURES AND FOIL

After end to end suture of a nerve there is always cause for concern on two accounts. *First*, will the suture line hold? *Second*, is there a neuroma forming at the site of suture?

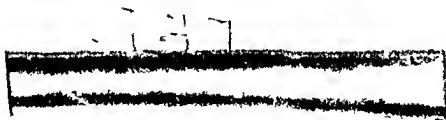


Fig. 453.—Roentgenogram mid thigh showing tantalum foil cuff around sciatic nerve with three circular restraining ties of tantalum wire about the cuff. Also note the sling suture and the seven small perineural sutures of tantalum wire.

The answers to these questions have usually been delayed many months until clinical signs of regeneration have or have not appeared. When metallic sutures and cuffs are used the answer may be surmised by regularly recording on roentgenograms the size of the foil cuff and the relative positions of each metallic suture (Fig. 453). If the anastomosis has separated presumably there would be a change in the relationship between the individual metallic sutures. If there is neuroma formation the tantalum cuff should progressively enlarge and this enlargement may be measured accurately on the roentgenograms.

Furthermore, it is not necessary that identical x ray techniques be used for one can calculate the relative sizes of the cuff by using measurements from one of the long bone images on the film to establish a mathematical ratio for comparison

SUMMARY

1 A technic for the repair of severed peripheral nerves using sutures of tantalum wire and a cuff of tantalum foil around the suture line has been described

2 Gross and histological evidence has been presented to indicate that (a) tantalum is inert in human tissues, and (b) scarring and fixation of repaired nerves can be reduced to a minimum by the judicious use of tantalum foil

3 The metallic sutures and foil can be helpful in determining the condition of the suture line both with respect to pulling apart of the anastomosis and later to the possibility of neuroma formation

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TREATMENT OF THE NEUROGENIC BLADDER AFTER ACUTE SPINAL INJURY*

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THE urinary bladder has two distinct functions storage and evacuation of urine. Urine is normally retained in the bladder at pressures under 12 mm of mercury. The desire to urinate is felt when the intravesical pressure exceeds 12 mm of mercury regardless of volume. The bladder is under cerebral control through reflex arcs in the brain and spinal cord therefore voluntary control of intravesical pressure is normally established. When cerebral control is lost by interruption of cerebrospinal pathways automatic voiding may occur under similar change of intravesical pressure.

The detrusor or large bladder muscle derives its motor innervation from parasympathetic fibers from the sacral cord. Sensation of vesical distention is recorded by nerve endings on the muscle bundles through nerves which pass by way of the second third and fourth dorsal sacral roots. Sensations of pain and temperature on the other hand are relayed through nerves to the thoracolumbar cord. Innervation of the blood vessels of the bladder the musculature of the trigonum vesicae and the ejaculatory apparatus is by the sympathetic nervous system from the thoracolumbar cord. We may consider the sympathetic innervation of the bladder as accessory and direct our attention to lesions of the parasympathetic nerves only in our discussion of neurological vesical dysfunction.

Since urination is controlled by reflex arcs through the spinal cord and brain any lesion of either the motor or sensory path

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ways may make the bladder inefficient either for storage or evacuation of urine.

Acute cerebrospinal injury may bring about immediate urinary retention. This condition has been described as due to spinal shock. It may be produced by swelling or hemorrhage around the cord with or without severance of bladder innervation. The acute situation is sometimes relieved within forty-eight hours when normal urination is reestablished. However, if normal urination is not reestablished within forty-eight hours we can be quite certain that damage to the bladder innervation has occurred.

SELECTION OF TREATMENT

Several methods of handling the urinary retention after acute cerebrospinal injury have been advocated. *Avoidance of urinary tract infection*, particularly of the upper tract, is of prime importance. Protection of the paralyzed bladder muscle has not been given sufficient consideration. During the first twenty-four hours after injury no urethral instrument should be passed except when rupture of the bladder or membranous urethra is suspected and passage of a diagnostic catheter is indicated. If the patient does not void on the second day a catheter may be passed and the bladder emptied. Decompression is not indicated in cases of neurological bladder. If a second catheterization is indicated the catheter should be left in place as a retention catheter. Interval catheterization is condemned because of the inevitable infection of residual urine and the danger of ascending infection during the interval between catheterizations when the intravesical pressure is elevated.

Since we can have no knowledge of how long drainage will be necessary, the use of the *retention catheter* preferably with *tidal irrigation* is considered logical. Tidal irrigation is not a treatment for the paralyzed muscle. It is simply a method of bladder irrigation which provides for more efficient function of the catheter and tends to prevent deep-seated catheter cystitis. The paralyzed muscle must not be overstretched; therefore the irrigation pressure must never exceed 12 mm. of mercury. Urethritis, an inevitable complication of urethral catheter drainage, can be kept at a minimum by the use of the Foley type of retention catheter. When this type of catheter is not available care must be taken to prevent external pressure on the urethra and

around the urethral orifice by the adhesive tape or other means of retaining the catheter

Suprapubic cystostomy has been advocated and performed by many surgeons as soon as possible after urination fails to develop following spinal injury. This is at best a poor method of bladder drainage in the neurogenic bladder. In spite of the variations of operative technic, special gadgets and various types of suction apparatus developed leakage occurs around the suprapubic tube. A dry bed is one of the most important factors in the prevention of decubitus. Cystitis and the formation of calculi occur as frequently as after urethral catheter drainage. Another method of prevention of decubitus is frequent change of position of the patient which procedure is limited by the suprapubic tube. There are instances when suprapubic cystostomy is indicated but it is not the best procedure for routine use. At least it should be withheld until it seems certain that long continued drainage is indicated and other methods are inadequate.

When the use of an urethral catheter is contraindicated, as in cases of stricture, urethritis or perineurethral abscess, *perineal or bulbar urethrostomy* has proved very satisfactory. This method of bladder drainage is simple, requires no special equipment and is adequate. In most cases of neurological bladder no anesthesia is required. A curved urethral sound is passed to the external sphincter and held by an assistant so that the urethral bulb is thrust toward the perineum. A 1 inch incision is made through skin, fascia, bulbar muscles and urethra down to the sound in one stroke. The edges of the urethra are held by Allis clamps while a large catheter is passed through the external sphincter and prostatic urethra into the bladder. The catheter is fastened and the wound closed with two chromic catgut or silk sutures. This method of drainage has distinct advantage over suprapubic cystostomy. There is no leakage around the catheter. After the initial dressing none is required. The catheter is readily replaced. The patient may be turned freely and may lie on his abdomen alternately with relief of pressure on the back, thus preventing decubitus. When drainage is discontinued, normal voiding may occur and no dressing is required. Tidal irrigation may be carried out and cystometry can be done, neither of which can be done satisfactorily with suprapubic drainage.

Recognizing the dangers of interval catheterization and of

open drainage of neurological bladders in World War I. Young ordered that these patients be left alone and *overflow incontinence* or automatic voiding be allowed to develop without the passage of any urethral instrument. Such treatment would prevent early infection of the urinary tract but residual urine does occasionally become infected whether the patient is catheterized or not. This method has a definite advantage as far as prevention of infection is concerned but it is a poor method of treatment of a paralyzed muscle. When one can be reasonably sure that automatic voiding will occur within forty-eight to fifty-six hours it is the method of choice. However it is rarely possible to estimate the degree of bladder nerve involvement within forty-eight hours after injury and no one has been able to follow up a substantial number of cases to know the end results. Automatic voiding is the exception rather than the rule within forty-eight hours after injury of the bladder nerves. Overflow incontinence with large amounts of residual urine must not be confused with automaticity.

TYPES OF SPINAL CORD LESIONS

In order to determine the best method of treatment of bladder dysfunction it would seem desirable to discuss the neurological lesions encountered and study illustrative cases. Since most of our patients were injured on other continents and were treated in various other hospitals before transfer to the Walter Reed General Hospital no standard method of treatment was carried out. Battle conditions made treatment and evacuation difficult.

Neurological lesions of the bladder are of four types. The *sensory lesion* is represented by the tabetic or cord bladder. It is most frequently seen in *tabes dorsalis*. It may be produced by section of the dorsal spinal roots bilaterally or by section of the sensory nerves which transmit reactions to stretch in the cauda equina or in the spinal cord. Reflex activity is lost. Sensation of bladder distention is lost or markedly diminished. Urinary retention occurs with overflow incontinence. If the diagnosis is made early before the muscle is atrophied, voluntary voiding may be accomplished by effort made at regular intervals. This method of treatment has been described as *clocked urination*. In the presence of infected residual urine drainage of the bladder is indicated to prevent ascending infection and to

relieve the paralyzed muscle and allow it to regain tone. The lesion is permanent.

Lesions of the motor pathways in the spinal cord or brain are more commonly seen in neurological disease than after injury. Spasticity of the detrusor with symptoms of urgency and frequency of urination are noted. There is markedly increased reflex activity as demonstrated by cystometric studies. When necessary, atropine or tropic acid derivatives may be administered to relieve symptoms. We have seen a few of these lesions in war surgery.

Lesions of the parasympathetic nerves between the spinal cord and bladder are uncommon. Because of the many roots and the complexity of the nerve plexus in the pelvis it is almost impossible to produce this lesion experimentally. We have observed two cases which seem to fall into this category. Loss of reflex activity with urinary retention occurs, however the patients have a good sensation of distention and it is on this point alone that the two lesions can be differentiated. The cystometric studies are quite alike showing complete loss of any voiding reflex and large bladder capacity but differ in that these patients have developed great straining power and can raise the intravesical pressure to heights normally required for voiding.

Transverse lesions of the spinal cord are most frequently seen in war surgery. Symptoms and prognosis depend upon the level of the extent of and the degree of atrophy of the spinal cord above and below the site of injury.

Bladder dysfunction after complete transection of the cord varies with the level of the lesion. As a rule the higher the transverse lesion, the more efficient the automatic bladder will be provided that there is minimum atrophy below the lesion. After transverse myelitis at the level of the seventh cervical or high dorsal vertebrae a very efficient automatic bladder results. Lesions above the seventh cervical are unfortunate since in our experience these patients have extensive atrophy of the cord below the lesion and automaticity cannot develop. Patients with transverse lesions in the mid dorsal region develop automatic voiding relatively early and the bladder is quite efficient with small amounts of residual urine. Complete transverse lesions at the level of the first lumbar vertebra and through the conus medullaris present a poor prognosis. These bladders behave very

much like atretic bladders. There is no reflex activity, no sensation of vesical filling. Retention is the rule and overflow incontinence is the result.

Fortunately most of our war injuries present a picture of *incomplete myelitis*. The cord is damaged or pressed upon by the bullet or fragment of shrapnel but is incompletely severed. With the onset of spinal shock the patient has urinary retention. The bladder nerves may or may not be severely damaged. When the pressure on the cord is relieved by the subsidence of swelling or as a result of surgery and decompression the bladder regains its function to a greater or less degree depending on the extent of the injury, the height of the lesion and the type of nerve involvement. The period of bladder dysfunction cannot be estimated in any given case. All spinal injuries are serious but since it is impossible to estimate the extent of the injury within forty-eight hours after injury, none of these cases should be regarded as hopeless.

ELECTIVE EARLY SURGERY

As a rule emergency surgery on the spinal cord is not indicated. The patient should be placed in position by padding, sandbagging or splinting or in a plaster cast so that further damage to the cord is prevented. When rapid improvement takes place surgery may be delayed or may not be indicated. However, when the lesion is progressive or the symptoms remain static, elective surgery may be indicated. We shall present some remarkable results of elective early surgical intervention in extensive cord injuries. The optimum results were obtained between the second and fifth days after injury. Late neurosurgery is indicated in a very few selected cases.

CASE I—L. W. T. Pvt. Engs. 36 years of age. Injured when thrown from a skidding truck Jan. 13, 1943 in India. Not unconscious but unable to stand. Examination showed anesthesia of ulnar surface of arms, diminished sensation of radial surfaces, bilateral anesthesia below nipple line, loss of position sense and loss of reflexes of lower extremities. No evidence of intracranial injury. Placed in head traction of 5 pounds. Catheterized 24 hours after injury. Chest and head cast applied. Indwelling catheter placed Jan. 29, 1943, cast replaced with patient in head traction and hyperextension. Diagnosis by x-ray of fracture of 6th cervical vertebra.

Feb 5 1943 patient, when blindfolded able to identify toes, leg, knee and external genitalia when touched Evacuated to United States by air

On Feb 21 1943 the patient was admitted to Walter Reed General Hospital Retention catheter replaced by Foley type catheter and tidal irrigation set up Urine grossly infected Severe decubitus noted over sacrum and in right gluteal fold Complete flaccid paralysis and sensory loss below level of C7 Slight evidence of mass reflex response Cast removed and patient placed on Striker frame Lumbar puncture showed free fluid at L3 March 6 1943 cystometric study showed no response to stretch No voiding reflex Pressure at 10 mm Hg with 50 cc in bladder at 12 mm with 150 cc and at 20 mm with 250 cc No sensation of distention Impression complete transverse section of cord at C7 June 5 1943 fever with chills Urine grossly infected Responded to sulfathiazole July 4 1943 no return of function No bladder reflexes Cystometric study showed no change July 14 1943 patient died Autopsy showed almost complete degeneration of the cord below C7 Complete transverse section of the cord at C6-7

Comment—This was a complete transection of the spinal cord produced by complete dislocation of the sixth on the seventh cervical vertebra with almost complete degeneration of the cord below the level of injury The findings at autopsy are consistent with the clinical picture and explain the failure of the reflexes to return There was only the slightest mass response The other findings were undoubtedly fanciful The patient was unable to comprehend his situation and could not cooperate We do not feel that early surgery would have benefited the patient In perfect drainage was established by urethral catheter There was evidence of marked cystitis ureteritis and pyelonephritis There was evidence of marked perivesical inflammation and we consider death to have been due to urinary tract infection with terminal septicemia

CASE II—L H Pfe Inf 23 years of age Injured by bullet Nov 10 1943 during landing operations in Africa The bullet penetrated the spinal cord at the level of D1 He was evacuated to a Naval Hospital Ship laminectomy was done the foreign body removed and decompression carried out He was admitted to Walter Reed General Hospital Nov 28 1943 There was complete loss of sensation below the level of D1 There was absence of decubitus reflexes

his thigh he would pass urine. Neurological Examination April 20 1943 Diminished sensitivity to touch and pain on the right side from D 10 to L 1. Band of hyperesthesia of L 1 segment. From L 2 to L 4 marked diminution of sensation to pain and touch but again at L 5 there is increase of sensitivity. Both sides of genitalia sensitive to pain and touch. Diminished sensation in saddle area. On the left side zone of hypesthesia from lower T 10 to L 1. Below L 1 hyperesthesia to pin and touch. Left leg cannot be moved. No hip flexion of right leg but leg can be flexed at the knee and at the ankle. Deep tendon reflexes active on both sides. Babinski 1 plus on right 4 plus on left. Abdominal reflexes absent. Slight cremasteric response. The patient had urgency but could control urination. Had rectal incontinence semi erections. Impression Modified Brown Sequard Syndrome.

On April 27 1943 laminectomy was performed. Bullet buried beneath fractured bone of posterior margin of 5th thoracic vertebra. Bullet exposed only after the spines and laminae of the 5th and 6th vertebrae had been removed and 5th roots sectioned bilaterally. Bullet removed intradurally. Dura closed with silk wound in usual manner. Catheterized 24 hours after operation 800 cc of urine being recovered. Indwelling catheter placed April 24 and removed May 1 1943. The patient was transferred and admitted to the Walter Reed General Hospital June 5 1943. He states that he lost complete voluntary motion of the right lower extremity after removal of the bullet. Anesthesia over L 4 segment with hyperesthesia over S 1 3 4 5 and L 2 and 3. Both knee kicks and ankle jerks increased. Mass reflexes of both legs. Involuntary voiding. Urine grossly cloudy. Fever treated by urinary antiseptics and daily bladder irrigations.

Comment—A gunshot wound resulted in hemisection of the cord at the fifth dorsal segment with a modified Brown Sequard syndrome. Following laminectomy there was urinary retention and eventually automatic voiding. The complete lesion of the bladder nerves terminated in a very efficient automatic bladder.

CASE VI—G B Cpl Inf 25 years old. Injured by machine gun fire Nov 17 1947. He suffered a compound fracture of the left humerus and a wound penetrated the spinal cord at the level of D 6. Indwelling catheter inserted. Left arm in aeroplane splint. X ray showed severely comminuted supracondylar fracture with many metallic foreign bodies scattered in the soft tissues. Dec 29 1947 suprapubic cystostomy. Neurological Examination. Complete mo

tor and sensory paralysis from the 5th dorsal segment down. On plantar stimulation there is slight flexion on both sides. There has been no return of function. April 17, 1943, body cast replaced. Markedly infected decubitus ulcer.

On April 27, 1943, the patient was transferred and admitted to the Walter Reed General Hospital Neurological Consultation. Patient was paralyzed from shoulders down over entire body immediately after injury. Regained use of arms in a few days and sensory level was at nipple line, then regressed to about 2 inches below the nipple line where it has been constant for 2 or 3 months. Has noted no paresthesia or any mass movements of the trunk or lower extremities at any time. Decubitus ulcers over sacrum trochanter and both heels. Left radial paralysis. Sensory level is at D 5 bilaterally. Complete paraplegia. No Babinski or mass reflexes obtained. No improvement of function in 3 months. Poor prognosis. April 30, 1943, Urological Consultation. Urine grossly infected. Fever with chills. Probability of upper urinary tract infection. X-ray negative for stone. Angulated suprapubic tube placed. There has been leakage around the tube and this is marked when patient is on his abdomen on the Striker frame. Cystometric study shows a small bladder which will accept only 100 cc. of fluid at which point there is definite sensation of fullness. The pressure is elevated after each increment. The pressure is sufficient for urination.

Comment—This patient has a complete lesion at the level of the fifth dorsal vertebra. After ten months there is a very poor bladder function. The cystitis from long suprapubic drainage has reduced his capacity. The prognosis is poor.

CASE VII—H. L. K., 1st Lt. Inf., 21 years of age. Injured March 5, 1943, by a falling tree limb. The diagnosis of compression fracture of 7th and 8th dorsal vertebrae was made. There was flaccid paralysis below the level of D 7. The patient was placed in hyperextension. Urinary retention was present. An indwelling catheter was placed and 800 cc. urine was obtained. March 8, 1943, patient conscious for first time. March 13, 1943, Neurological Examination.

Skin anesthesia below costal borders. Plantar reflexes weakly positive. Abdominals absent. March 14, 1943, laminectomy. Collapse of 7th and 8th dorsal vertebral bodies noted. Ligamentum flavum thickened and cord herniated into opening in laminae. Dura incised followed by gush of spinal fluid. Probing between dura and cord allowed more fluid to escape. No clot found. Several pieces of fibrin removed. Dura closed with silk and wound closed in usual

manner The catheter which was removed before operation was replaced March 15 1943 March 16 plantar reflexes active March 19 sensation to pin prick noted to level of umbilicus March 20 muscles of lower extremity respond to foradic stimuli March 23 pin prick sensation felt to level of iliac crests March 24 urethritis acute with chills and a temperature of 102°F Catheter removed followed by overflow incontinence March 29 retention catheter replaced Closed type of intermittent irrigation set up April 2 catheter replaced by Foley type retention catheter Recurrence of chills and fever Diagnosis of pyelonephritis made

On April 16 the patient was transferred and admitted to Walter Reed General Hospital Tidal irrigation at pressure of 12 mm Hg was set up April 26 recurrent chills and fever Tidal irrigation and sulfathiazole continued to July 5 Cystometric study showed a bladder capacity of 300 cc There was no response to stretch no voiding reflex There have been some flexion contractions of the legs July 9 recurrent chills and fever relieved by sulfathiazole Aug 5 recurrent chills and fever Urethritis marked Perineal urethrostomy Aug 10 1943 patient up in wheel chair Very satisfactory drainage by urethrostomy

Comment—This patient has an incomplete lesion at the seventh dorsal vertebra The prognosis is poor No automaticity of bladder function is present after seven months Perineal urethrostomy drainage was undertaken because of severe urethritis

CASE VIII—C F M Pfc Engs 23 years of age Injured Dec 7 1942 when he accidentally fell off troop train in India There was fracture of D 9 and L 1 with transection of the cord at the level of D 10 He was treated in hyperextension and the bladder was drained by urethral catheter from the date of injury to the time of admission to the Walter Reed General Hospital Jan 23 1943 There was evidence of complete loss of sensation below the level of D 10 with loss of deep and superficial reflexes There was no sensation of bladder fullness Retention catheter drainage was continued with change of the catheter every fifth day However the patient developed a perineal abscess at the penoscrotal juncture and penineal urethrostomy was carried out March 12 1943 No anesthesia was required A No 28 Malecot drain was introduced through a 1 inch incision in the bulbous urethra March 20 1943 cystometric studies showed the first response to stretch There was good accommodation on increments of 50 cc After 100 cc had been introduced there was a strong contraction and a voiding reflex which

caused voiding around the catheter. There was no sensation of bladder fullness and the patient did not feel the passage of urine through the urethra. The perineal tube was removed. The patient had interval involuntary voiding through the perineum for 4 days followed by healing of the wound and normal passage by the urethra. He was discharged from this hospital and entered the Veterans Facility June 8, 1943, at which time he had a very satisfactory automatic bladder with no residual urine.

Comment—This was a case of complete transection of the spinal cord at the level of the tenth dorsal vertebra with development of an extraordinarily efficient automatic bladder 110 days after injury. The complication of perineal abscess required perineal urethrostomy drainage which was very efficient. The Striker frame allowed the patient to be turned frequently and we consider the use of this apparatus to have been most valuable in the treatment of his large decubitus ulcers which healed.

CASE IX—F F M T/4 C A C 26 years old Wounded Aug 25, 1942. The bullet passed through the left arm at the elbow into the abdomen and entered the spine at the level of D 12 producing immediate flaccid paralysis of the legs. He lost bladder and bowel function. Laparotomy. Point of entrance was found to be the 10th interspace left posterior axillary line. A wound of the diaphragm and perforating wounds of the upper pole left kidney and of the spleen with hemorrhage were present. A perforating wound of the spine at the 11th interspace had severed spinal cord. The bullet lodged immediately beneath integument to the right of 11th dorsal vertebra. Suture of diaphragm splenectomy drainage of perirenal space. On Sept 17, 1942 the patient was transferred and admitted to the Walter Reed General Hospital. Flaccid bilat paralysis of legs. Reflexes of legs cremasterics and lower abdominal reflexes absent. Sensation completely lost to D 12 diminished to D 10. Decubitus ulcers over sacrum and heels. Sept 25, 1942 Urological Consultation. The patient had been wearing a retention catheter since injury. He had no desire to void when the tube was not functioning well. Cystometric study showed good response to stretch with reaction after each increment after the second of 50 cc. After 300 cc had been introduced the pressure reached 40 mm Hg but there was no voiding and no sensation of fullness. Reading rechecked. Placed on tidal irrigation. Dec 21, 1942 had good automatic voiding with no residual urine. Cystometric study showed remarkable return of reflex bladder activity. There was no response

to stretch until the pressure exceeded 12 mm Hg when a good voiding reflex was noted. No sensation of fullness.

Comment—This is a particularly interesting case of injury of the eleventh dorsal segment with complete paralysis of the legs but a return of automatic bladder function after eighty-eight days. While up in a wheel chair the patient is able to anticipate urination and voids every hour. When in bed he voids every two to three hours. Urination is completely automatic and cannot be controlled.

CASE V—D N K Sgt Engs 41 years of age. Injured Nov 20 1942 when he was struck by a crane. He suffered compression fractures of the 11th dorsal and the 1st thoracic vertebrae. There was loss of sensation below the level of T1 with neurological findings interpreted as a complete transverse lesion at this level. The patient was transferred and admitted to the Walter Reed General Hospital Feb 14 1943. A urethral retention catheter had been placed. This drainage was continued with tidal irrigation at 12 mm Hg pressure. Cystometric studies showed no reaction to stretch Feb 18 1943. Laminectomy was carried out. A total block was demonstrated. The cord was freed and decompression carried out. Cystometric studies March 20 1943 showed considerable return of bladder reaction to stretch. After each increment of 50 cc there was a definite stretch reflex. However no voiding reflex developed. The catheter was removed temporarily but there was only overflow incontinence and drainage was reestablished. Because of the development of a periurethral abscess at the penoscrotal junction perineal urethrostomy was carried out April 13 1944. No anesthesia was required. A No 28 Malecot drain was introduced through a 1 inch incision in the urethral bulb. Very adequate bladder drainage was established. Tidal irrigation was carried out through the penneal tube. Further cystometric studies showed no development of reflex bladder function. The patient was transferred to a Veterans Facility June 4 1943.

Comment—This was a case of complete transverse section of the spinal cord at the level of the first lumbar vertebra. There was complete interruption of the sensory and motor innervation of the bladder until the time of laminectomy. Following this operation there was some return of stretch reaction although automaticity did not develop. There are insufficient reflex arcs

retained to allow automatic voiding. Perineal urethrostomy provided a very satisfactory means of drainage of the bladder after a periurethral abscess forced us to discontinue urethral catheter drainage.

CASE XI—J McG S/Sgt Inf Injured when struck by a truck Oct 2 1942. He suffered posterior dislocation of the right hip extensive wound of the right thigh and leg and was paralyzed from the hips down. Neurological examination indicated spinal lesion at the level of L1. X rays showed compression fracture of L1. He was catheterized twenty four hours after injury because of retention and 780 cc of urine recovered. It was noted that at the time of catheterization there was a purulent urethral discharge. In spite of this a retention catheter was placed. He was given sulfathiazole gm 1 every two hours. He had high fever to Oct 5 1942. Neurological Consultation. Complete loss of pain touch temperature and muscle tendon sense on both sides below the level of the I1 dermatome with a zone of hyperesthesia over D12 dermatome. Tendon reflexes abolished in the legs. Nov 10 1942 he had fever with chill. Marked costovertebral angle tenderness bilaterally. Purulent urine. Diagnosis pyelonephritis acute. Treated successfully with sulfathiazole. Transferred by air and admitted to Walter Reed General Hospital Nov 23 1942. Urethral catheter in place. Tidal irrigation resumed. Cystometric studies revealed good accommodation of fluid increments. There was no evidence of reflex activity. Study of bladder activity using a water manometer shows frequent 1 cm contraction waves typical of the myoneural contractures seen after complete transverse lesions at L1. Dec 23 1942 cystometric study indicated slight reflex activity and considerable increase in tone. However there were no voiding responses. Laminectomy was done. The cord was freed of adhesions no blockage was demonstrated. Jan 16 1943 cystometric studies show slight reaction to stretch but no voiding reflex. Restudy Feb 22 1943 indicated no change. Because of development of a periurethral abscess at the penoscrotal juncture perineal urethrostomy was done Feb 15 1943. A No 28 Malecot drain was inserted through a 1 inch incision in the bulb of the urethra. Efficient drainage was established. Several bladder calculi were removed through a panendoscope sheath. March 28 1943 a large calculus was crushed with a Bigelow lithotrite the small pieces were broken up with a large Young rongeur and the fragments evacuated through a panendoscope sheath. The perineal urethrotomy tube was replaced. Tidal irrigation was carried out through the perineal tube. After several bouts of chills and fever

the patient was transferred to a Veterans Facility in the region of his home

Comment—This is a case of almost complete lesion of the bladder innervation. No reflex activity has been noted. Complete loss of sensation of distention is present and pain is noted. The differentiation between a tabetic type of bladder lesion and a complete motor and sensory lesion is made by cystometry. The small contraction waves represent muscular contractions without reflex control from the spinal cord. Perineal urethrostomy was carried out for bladder drainage after a periurethral abscess developed. This method of drainage was very satisfactory and allowed tidal irrigation to be used successfully. Calculi were removed through this wound. This patient should have had suprapubic drainage at the time of injury in the face of acute urethritis. There is little likelihood of any return of function and automaticity has not developed because the spinal injury cut all reflex arcs to the bladder.

CASE XII—W A H Cpl Inf 24 years of age Injured March 21 1943 when a land mine exploded under the vehicle in which he was riding in Africa. Suprapubic cystostomy had been done shortly after injury. This tube was removed and a retention catheter was placed on arrival at the 12th General Hospital April 4 1943. Laminectomy was done. The body of L1 was found to be displaced posteriorly while the lamina and arch of L2 was found to be displaced anteriorly. There was fracture of the lamina of L1. Subarachnoid hemorrhage surrounded the conus medullaris and cauda equina. Removal of clots and fibrin was followed by free flow of spinal fluid from above the lesion. Pulsation of cord noted. The dura was closed loosely. May 7 1943 acute epididymitis right. May 9 1943 retention catheter removed. No voiding but some overflow with bladder distention. Catheterized every 8 hours. May 12 1943 reinfection of epididymis with orchitis. May 13 1943 epididymotomy right. Voiding occurred in small quantities but a residual urine of 450 cc was present. May 27 1943 patient was able to move both legs but had bilateral foot drop. Involuntary voiding. May 31 1943 exposed portion of testis gangrenous.

On June 15 1943 the patient was transferred and admitted to Walter Reed General Hospital. He was voiding automatically with less than 25 cc residual urine. June 17 1943 orchidectomy right. Neurological Consultation. Severe compression fracture L1 Level

of anesthesia to L1 dermatome Weakness of abdominal thigh and hamstring muscles with some retention of power Loss of tibialis anticus function with foot drop and of functions of peroneal gas trocnemus tibialis posticus flexors and extensors of toes Abdominal cremasteric patellar and Achilles reflexes are absent There is a possibility of considerable return of function Start physical therapy Cystometric study indicates excessive reflex activity of the bladder Voiding reflexes are noted after each increment of 50 cc Voiding pressure 64 mm Hg Bladder infection effectively treated with sulfathiazole Urgency noted

Comment—In this instance an incomplete lesion occurred in the first lumbar segment Early operation relieved cord pressure and allowed return of function to those nerves which were not severed or irreparably damaged There was immediate urinary retention with spinal shock We have no notes on the early days after injury but we may assume that battle conditions prevented earlier correction of the lumbar defect with freeing of the compressed nerve fibers Had this been possible suprapubic cystostomy may not have been necessary The bladder nerve lesion is typical of involvement of the motor fibers above the cauda equina This is not an automatic bladder Urgency and frequency indicate good sensation of distention The patient is not able to control urination because the innervation to the external sphincter is lost Therefore the reflex between the sphincter and the detrusor is incompetent With clearing of infection we expect increase in bladder capacity and a return to relatively normal urination

CASE VIII—A. K. G. S/Stg. A. A. F., 26 years of age Injured Dec 8 1942 in a plane crash Unconscious with apparently severe brain injury and extensive wounds of face The following diagnoses were made Fracture simple complete of lower third left of femur fracture simple incomplete right of talus fractures compound complete of symphysis mandibulae maxilla (bilateral) nasal (bilateral) frontal (bilateral) fractures simple complete of condyle of mandible (bilateral) malar bones (bilateral) compression fracture of 1st lumbar vertebra with traumatic myelitis The patient was restless, uncooperative and required paraldehyde for control Because of his condition it was difficult to keep him in hyperextension He was catheterized daily for the first 4 days On Dec 12 1942 traction to the fractured femur was applied

under pentothal sodium anesthesia Dec 18 1942 cast with traction on jaws applied On the same day a recheck showed continued saddle anesthesia The patient was unable to dorsiflex either ankle Bilateral anesthesia was present over great toes Note Dec 31 1942

Back injury suspected on admission but general condition of patient did not allow plaster fixation of back Attempt to keep spinal column hyperextended failed due to disposition of patient Cast applied in hyperextension Within 12 hours after hyperextension was applied the patient voided for the first time since injury Sensation was returning to toes and perineum and he could move his toes His condition improved to Jan 29 1943 when cast was removed

The patient was transferred and admitted to Walter Reed General Hospital Jan 27 1943 He was able to move his right leg X rays show compression fracture of 1st lumbar vertebrae and posterior dislocation of lower fragment of fractured femur with $\frac{1}{2}$ inch overriding Involuntary voiding with gross infection of the urine Fecal incontinence Moves right leg Unable to move toes of left foot Both plantar reflexes hypoactive Right Achilles reflex absent Loss of sensation in entire left foot Loss of pin prick sensation over area supplied by 1st and 2nd sacral dermatomes Jan 30 1943 urological note Unusual L 1 lesion Incomplete automatic voiding with at times some desire to void but unable to control act He feels the passage of urine through the urethra Feb 11 1943 because of gross infection of the urine a retention catheter was placed and tidal irrigation set up to aid in clearing the infection Cystometric studies indicated good response to stretch sensation of bladder fullness with good voiding reflex The patient was unable to stop the urinary stream He has been voiding 200 cc every 2 hours May 7 1943

Continues automatic or uncontrolled urination has frequent fecal impaction Femur healed Paralysis of muscles of left leg and lack of sensation below the knee May 21 1943 patient was up in wheel chair June 5 1943 he started walking with ischio caliper and drop foot splints with Taylor back support He still has uncontrolled voiding but can get the urinal in time if available

Comment—This case represents an incomplete lesion of the cauda equina below the first lumbar vertebra with involvement of the innervation to the left leg anal sphincter and the perineal nerve which supplies the external sphincter There is involvement of the motor nerves to the bladder with urgency and frequency Urination is uncontrolled because of loss of reflexes between the external sphincter and the detrusor Considerable more improvement can be expected

CASE XIV—G H H Pvt Arm Div 23 years old Injured Nov 7 1943 at 3 A M when he fell 70 feet to the ground from a flat car standing on a trestle He was admitted to Walter Reed General Hospital from troop train at 3 P M conscious lying on a litter with spine in hyperextension He was put to bed in hyperextension Pain was present at L 1 weakness of leg muscles patellar reflexes diminished but present Achilles reflexes not obtained Loss of sensation below level of L 1 X ray shows a mild compression fracture of L 1 No bladder discomfort or distention is present Nov 8 1943 no voiding bladder to umbilicus No return of leg function 11 P M bladder above umbilicus Retention catheter passed and tidal irrigation set up Nov 13 1943 Neurosurgical Consultation Incomplete motor and sensory lesion at L 1 Patellar reflexes obtained on reinforcement Achilles reflexes absent Cremaster and lower abdominal reflexes obtained with difficulty Diffuse motor weakness of lumbosacral distribution A body cast in hyperextension was applied Laminectomy at L 1 through window cut in cast Angulation of the cord demonstrated Compression of cord from anterior fragments and from posterior dislocation Thorough decompression done Dura not opened Spinal fusion Cystometric studies on Nov 20 1943 and Nov 26 1943 showed trabecular type of bladder with no response to stretch no voiding reflex The bladder held 600 cc on each occasion Dec 4 1943 cystometric study showed good response to stretch and the catheter was ejected on 150 cc Good voiding reflex Catheter removed followed by involuntary voiding which continued to Dec 24 1943 when the patient noted definite sensation of distention and was able to get the urinal in time Jan 15 1943 patient walking a little in his cast Feb 8 1943 complication of acute thrombophlebitis appeared May 6 1943 the patient was put on ambulatory ward wearing back brace and elastic stocking and on hyperextension exercises Bladder function normal He can control urination perfectly May 17 1943 patient left on thirty days sick furlough

Comment—This patient suffered a compression fracture of the first lumbar vertebra with symptoms due to cord compression Early operation relieved pressure and allowed return of function within six weeks after injury

SUMMARY

Fourteen cases have been presented Cases I III IV VI VIII IX X and XI represent complete transverse sections of the cord at the levels of the sixth cervical fourth dorsal fourth

dorsal fifth dorsal tenth dorsal eleventh dorsal first lumbar and first lumbar vertebrae respectively. In the first case a complete transection of the sixth cervical segment caused degeneration of the cord below that level and no automaticity developed. Two lesions of the fourth dorsal segment, one of the sixth dorsal and lesions of the tenth and eleventh dorsal segments resulted in automatic voiding. Two lesions of the first lumbar segment resulted in complete loss of reflex activity of the bladder.

Case XIV represents a complete physiologic lesion of the first lumbar segment resulting in spinal shock. Early relief of compression by laminectomy freed the nerves and normal urination was resumed forty seven days after injury.

Cases II V VII XII and XIII represent incomplete lesions of the first, fifth and seventh dorsal segments and two of the first lumbar segment. Spinal shock caused retention of urine in all cases. This was followed by automatic voiding in Cases II and V at levels of the first and fifth dorsal vertebrae. There is still some possibility of return to normalcy in Case II. Case VII with an incomplete lesion of the seventh dorsal segment still has loss of bladder reflexes after seven months. In this case there may be degeneration of the cord below the site of injury. Two lesions of the first lumbar segment caused immediate retention due to spinal shock. This was followed by inefficient involuntary voiding and eventually the compression changes cleared to show a simple motor lesion of the bladder nerves with resultant urgency and frequency. Urination could not be interrupted due to loss of external arethral sphincter control.

CONCLUSIONS

Spinal cord injuries cause symptoms by anatomical or physiological interruption of nerve fibers. Actual differentiation can not be made immediately after injury except by observation of the cord after laminectomy. Anatomical lesions may be complete (transverse myelitis) or incomplete. The spinal lesion may be incomplete while lesion of the bladder nerves may be complete or partial. The physiological lesion is produced by compression, edema or hemorrhage in or around the cord. Symptoms may clear rapidly or may persist until the cord compression is relieved surgically.

The first consideration insofar as the urologist is concerned is prevention of urinary tract infection. This can best be accomplished by the principle of 'no instrumentation'. However the paralyzed muscle must be protected.

Because it is practically impossible to differentiate the anatomical from the physiological types of lesion we advise no urethral instrumentation for thirty six hours. Then the patient may be catheterized if necessary under strict aseptic conditions. If a second catheterization is indicated the catheter should be left in place for drainage preferably with tidal irrigation. The irrigation pressure must never exceed 12 mm of mercury and the system is efficient at pressure as low as 6 mm of mercury.

If long continued drainage is necessary we recommend perineal urethrostomy. Acute or severe urethritis of the anterior urethra is common during drainage and is a definite indication for other type of drainage.

We would reserve suprapubic cystostomy for complicated cases in which urethrostomy is impractical because of stricture, large vesical calculus formation or prostatic abscess.

Drainage should be continued, the catheter changed every fifth day and the bladder irrigated regularly until signs of returning bladder reflex activity are noted. This can be determined occasionally by a sensation of bladder distention or of voiding. Usually, however, we can determine the time for removal of drainage by cystometry far in advance of clinical symptoms.

Cystometry is a method of studying bladder reflexes. The cystometric findings in addition to reflex and sensory neurologic data complete the picture.

Early neurologic surgery to relieve pressure on the spinal cord is recommended. This should not be performed in the acute stage of shock but may be safely done from two to five days after injury.

TRAUMATIC ARTERIOVENOUS ANEURYSM*

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TRAUMATIC arteriovenous aneurysms are predominately the result of shell fragment knife and bullet wounds of the great vessels and while these lesions may occur at any time their number increases markedly in time of war. No figures can be given of the incidence of this injury among the wounded in the present war. However the official British Medical History of World War I records that among 1004 injuries to the great blood vessels arteriovenous aneurysms developed in 254 and Makins personally observed 152 cases.

PATHOGENESIS

To understand the development of these aneurysms and their relation to other traumatic vascular injuries it is necessary to discuss what may occur as a result of a penetrating wound of the blood vessels. When an artery is penetrated and the external wound is small immediate hemorrhage into surrounding tissue occurs with a resulting hematoma. Depending upon the size of the vascular wound and its relation to fascial planes the hematoma will be diffuse or circumscribed. If the vascular wound is large and the fascial plane extensive a diffuse hematoma forms and bleeding into the tissue continues until pressure on collateral vessels results in peripheral ischemia. If the fascia is unyielding and the vascular laceration small a circumscribed hematoma forms which becomes firmly organized peripherally but remains soft centrally where it is in contact with the arterial wound. The blood streaming out of the arterial perforation into the hematoma gradually excavates a cavity which increases in size and becomes lined with smooth endothelium continuous with the arterial intima while its outer wall is formed by lumen

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nated blood clot and fibrous tissue. The result is a traumatic arterial saccular aneurysm.

The development of an arteriovenous aneurysm is similar. When all walls of both artery and vein are penetrated, a hematoma forms about the outer arterial laceration while the edges of the laceration on the inner side heal with those of the ad-

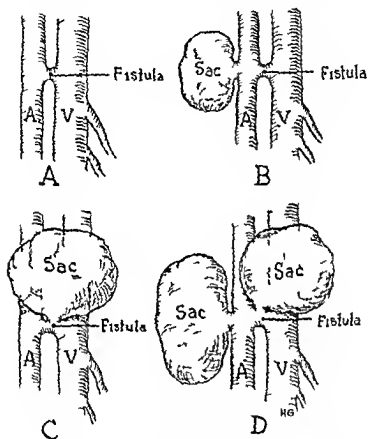


Fig. 454—Examples of arteriovenous fistulas. A Aneurysmal variety. B, C, D) Fistulae and aneurysms. (Army Medical School)

jacent vein forming an arteriovenous anastomosis. The laceration on the outer side of the vein closes while the hematoma about the arterial laceration becomes excavated and a sac is formed. The result is a communication between the artery and vein together with a saccular aneurysm connected with the artery. This saccular form of arteriovenous aneurysm is termed

a *varicose aneurysm*, and it develops in a variety of anatomical forms depending upon the size and location of the arterial and venous lacerations the extent and tensile strength of the resulting cicatrix and the elasticity of surrounding structures Several of these variations are outlined in Figure 454 B, C, D

An *aneurysmal varix* is a simple arteriovenous fistula in which there is an anastomosis between the artery and vein without a sac (Fig 454 A) This remarkable form results from a missile passing directly between a parallel artery and vein lacerating the adjacent walls Immediate adherence of the artery and vein occurs allowing little hemorrhage while the edges of the lacerations heal forming a fistula between the vessels An aneurysmal varix may also result from a small penetrating wound which traverses both artery and vein and the lacerations on the outer walls of the vessels heal

ANEURYSMAL VARIX

Case Report

R J S white male a private first class aged twenty eight years was admitted to Walter Reed General Hospital November 28 1942 This soldier sustained shell fragment wounds of his right axilla on November 10 1942 at Casablanca North Africa There was only moderate external bleeding He received first aid treatment one hour after the injury at which time a definite bruit and thrill in the region of the axillary wound were noted The patient himself noted the presence of the thrill three weeks after the injury and at that time observed that his right hand was colder than his left He had noted no shortness of breath or precordial discomfort

Physical Examination—The general physical examination was negative Examination of the right axillary region revealed a small healed wound on the outer surface of the arm over the deltoid muscle and three small wounds in the axilla There was an oval compressible swelling 3.5 cm in length and 2.5 cm in diameter in the axilla (Fig 455) On palpation of the mass a continuous thrill with systolic accentuation was noted Auscultation revealed a continuous roaring machinery like bruit accentuated at systole and transmitted upward into the right supraclavicular area and downward to the lower third of the arm There was moderate dilatation of the peripheral veins of the right arm and forearm The right radial pulse was barely perceptible The blood pressure in the right arm was 82/46 in the left arm 114/60 The skin temperature determined by the thermocouple was markedly diminished in the

right hand the right third finger being 86 F the left third finger 90.9 F. A venogram taken December 10, 1942, showed a sudden increase in the size of the axillary vein in the region of the gunshot wound with definite deformity of the vein distal to the dilated area. Examination of the heart revealed no enlargement. A teleoroentgenogram revealed the transverse diameter of the heart to be 11.5 cm, the internal diameter of the chest 29.5 cm. An electrocardiogram was negative. On complete obliteration of the fistula there



FIG. 455—Location of aneurysm in the right axilla. Note healed shell fragment. (Army Medical School)

was definite slowing of the pulse and occasionally an increase in the blood pressure, the diastolic elevation being most marked.

	Pulse	Before Compression	Pulse	After Compression
		Blood Pressure		Diastolic Pressure
Dec 7 1941	66	114/60	66	126/80
Dec 12 1942	76	104/67	72	104/6
Jan 14 1943	76	112/66	7	116/68
Feb 0 1943	76	102/76	68	110/8
Feb 3 1943	64	114/58	55	100/64

The Moscheowitz Matas hyperemic test on February 25 1943 demonstrated the presence of adequate collateral circulation in the right upper extremity

Operation—March 15 1943 An incision was made on the medial aspect of the upper third of the right arm extending

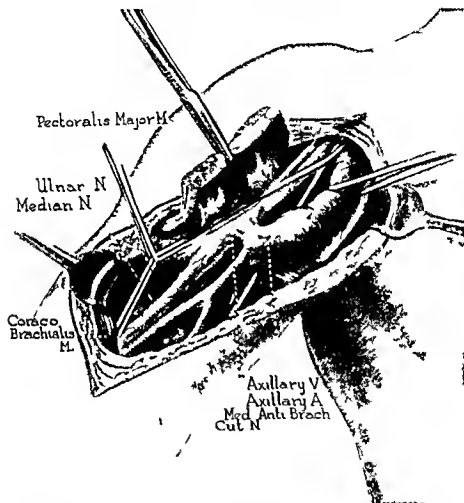


Fig 456—Arteriovenous fistula between the axillary vessels The axillary vein proximal to the fistula is tremendously dilated (Army Medical Museum)

across the anterior axillary fold to the clavicle The deep fascia was incised and the brachial vessels identified The brachial artery and vein were isolated 3 cm below the insertion of the latissimus dorsi and tapes placed about them The pectoralis major muscle was incised in its outer third between mattress sutures The axillary artery and vein were then isolated and

right hand the right third finger being 86 F the left third finger 90.9 F A venogram taken December 10 1942 showed a sudden increase in the size of the axillary vein in the region of the gunshot wound with definite deformity of the vein distal to the dilated area Examination of the heart revealed no enlargement A teleoroentgenogram revealed the transverse diameter of the heart to be 11.5 cm the internal diameter of the chest 29.5 cm An electrocardiogram was negative On complete obliteration of the fistula there



Fig 435—Position of artery in the right axilla Note healed shell fragment site (Army Medical School)

was definite slowing of the pulse and occasionally an increase in the blood pressure the diastolic elevation being most marked

			B for Compres	After Compression	
			Pulse	Blood Pressure	Pulse Blood Pressure
Dec	7	194	76	114/60	66 116/80
Dec	12	194	76	104/62	72 104/6
Feb	14	1943	76	112/66	7 116/68
Feb	20	1943	76	107/76	68 110/8
Mar	3	1943	64	114/58	55 100/64

PROCEDURE With the four vessels proximal and distal to the fistula controlled the dissection of the varix was undertaken. The median, ulnar and antibrachial cutaneous nerves were identified and protected. The axillary artery was freed 3 cm above and below the fistula and a similar procedure was followed with the axillary vein. Quadruple ligation was then performed using



Fig. 458—The specimen removed at operation showing the opened artery with the fistula partially closed by a thrombus (Army Medical School)

umbilical tape for the proximal artery and vein and heavy silk for the distal artery and vein. The fistula including the four vascular segments, was then excised (Fig. 457). The deep fascia in the arm was closed and the cut edges of the pectoralis major approximated. The superficial fascia and skin were closed with out drainage. Silk sutures were used throughout.

The specimen (Fig. 458) consisted of a segment of artery

and vein connected by a thin walled fibrous tissue fistulous tract. An organized thrombus protruded from the arterial opening of the tract into the lumen of the artery partially closing the fistula. There were two valves in the vein 2 mm distal to the fistula.

Postoperative Course—Immediately following operation the circulation of the right upper extremity was excellent and at no time subsequently was there any peripheral circulatory embarrassment. The radial pulse was palpable on the fourth postoperative day. The wound healed per primam.

Results—Examination three months after operation showed the right hand to be as warm as the left, a good right radial pulse and no evidence of recurrence of the fistula. The soldier was returned to full military duty.

Remarks

The development of a thrill and bruit immediately after injury is typical of an aneurysmal varix. In this patient the arteriovenous anastomosis was formed coincident with the vascular wounds and the minimal surrounding hemorrhage did not obscure the clinical signs.

Occasionally an arteriovenous fistula will close spontaneously. Reid and McGuire, Pozzi and Rontier have reported cases with unmistakable evidence of complete healing. A remarkable example of the manner in which spontaneous healing may occur is illustrated in the specimen from this case. The organized thrombus arising in the fistulous tract partially occluded it and had the thrombus been larger or the tract smaller complete obliteration might have occurred.

Dilatation of the vein proximal and distal to the fistula is the usual finding. In this case the proximal vein was enormously dilated while the distal vein was constricted. This can be explained by the presence of the two valves in the vein distal to the fistula which undoubtedly directed the full force of the arterial blood into the proximal vein allowing only a small amount of blood to flow distally.

The absence of cardiac symptoms is significant for one of the most constant late effects of an arteriovenous anastomosis is cardiac dilatation, myocarditis or decompensation.

VARICOSE ANEURYSM WITH ASSOCIATED CARDIAC DILATATION

Case Report

F V C white male a technical sergeant aged twenty five years was admitted to Walter Reed General Hospital January 29 1943 Six months before admission while cutting papers with a boning knife the patient accidentally plunged the knife into the middle third of his right thigh There was an immediate spurt of blood from the wound which was controlled by a tourniquet At the Station Hospital bleeding was stopped by local pressure and the

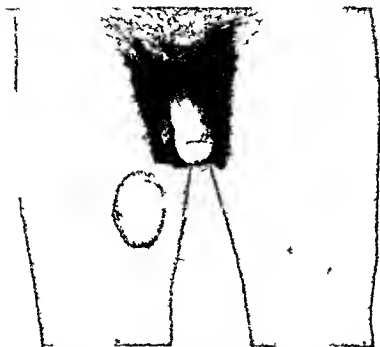


Fig 459—Showing position of arteriovenous aneurysm in the right thigh (Army Medical School)

skin wound was sutured One week following the injury the patient noted a pulsating purring swelling at the site of the stab wound and described a wide area of ecchymosis extending from the midthigh to the ankle The ecchymosis gradually disappeared but the local swelling persisted Shortness of breath associated with precordial pain on exertion and when lying on the left side was first noted three weeks following the injury and had persisted up to the time of admission

Physical Examination—The patient was a stocky moderately obese soldier not appearing acutely ill The heart was enlarged moderately to the left No murmurs were present On the antero

medial surface of the middle third of the right thigh there was a soft, compressible, oval swelling 8 by 6 cm over which a rough continuous thrill was palpated (Fig 459). On auscultation a continuous roaring murmur was heard increasing in intensity at each systole but diminishing and becoming softer at diastole. This bruit was transmitted over the medial and anterior surfaces of the thigh from the inguinal ligament to the knee. The superficial veins of the right thigh and leg were dilated and there was an increase in the circumference of the right thigh. The right dorsalis pedis and posterior tibial pulses were diminished. The right popliteal blood pressure was 130/80 the left 158/80. Obliteration of the fistula by compression gave typical pulse and blood pressure changes.

	Before Compression		After Compression	
	Pulse	Blood Pressure	Pulse	Blood Pressure
Jan 29 1943	96	112/60	92	112/80
Feb 8 1943	76	109/70	68	114/86
Feb 10 1943	100	128/70	90	132/86

A teleroentgenogram taken January 29 1943 revealed the transverse diameter of the heart to be 15 cm (Fig 463 upper). An electrocardiogram on January 30 1943 showed the QRS waves slurred in all leads. There was a left axis deviation of minus 32 degrees and the T wave was inverted in Lead IV.

Operation—February 15 1943. Under continuous spinal anesthesia an incision 30 cm in length was made over the course of the femoral vessels. A tourniquet was not used. An oval aneurysm sac measuring 7.5 by 5 cm was found overlying the femoral vessels at the apex of Scarpa's triangle covered by and adherent to the sartorius muscle. The proximal femoral artery was markedly enlarged and thin walled. The proximal femoral vein was also dilated and eddies of blood synchronous with each systole were seen through its wall. The vessels distal to the aneurysm showed marked changes: the artery was small being one half normal size while the vein was large and dilated (Fig 460).

PROCEDURE The femoral artery and vein proximal and distal to the sac were isolated and tapes placed about them but not tied. The sac was freed from the sartorius adductor longus and vastus medialis muscles; the saphenous nerve and the nerve to the vastus medialis being first identified and protected. Numerous collateral vessels requiring ligation were encountered. The

proximal artery was ligated with umbilical tape and transfixed with a silk suture. A similar ligation and transfexion was performed on the distal artery and the proximal and distal vein. The sac together with the segments of the femoral artery and

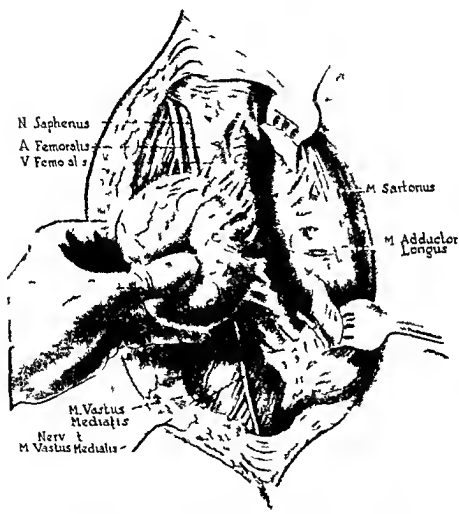


Fig. 460—Findings at operation showing the arteriovenous aneurysm between the femoral vessels (Army Medical Museum)

vein containing the fistula was excised (Fig. 461). At the close of the six hour operation the foot was warm, the blood pressure was 118 systolic and 78 diastolic and the pulse was 68.

The specimen (Fig. 462) consisted of a segment of femoral artery and vein with a communication 5 cm. in diameter be-

tween the vessels. There was an egg shaped aneurysmal sac measuring 7.5 by 6 by 4 cm which communicated with the fistulous tract through an opening 4 mm in diameter (Fig 454 C). The lining of the sac was smooth and gray white resem

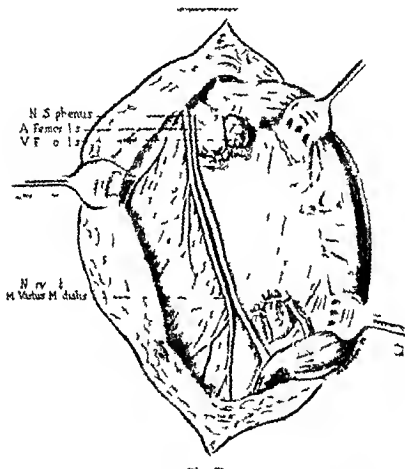


Fig 461—The operation completed. Note the size of the vessels proximal and distal to the aneurysm. (Army Medical Museum)

bling intima and the wall was fibrous measuring 2 mm in thickness.

Postoperative Course—The right foot and leg remained warm and pink throughout convalescence although the dorsalis pedis pulse could not be felt. The precordial pain disappeared and the patient could lie on his left side without discomfort. A teleo

roentgenogram taken March 6, 1943, on the nineteenth post operative day showed a remarkable change in the appearance of the heart and chest. The transverse diameter of the heart had diminished from 15 cm to 11.4 cm and the vascular markings in the lung field were no longer prominent (Fig 463 lower).

Results—Examination of the patient four months after operation showed excellent circulation in the right extremity and pal



Fig 467—The specimen removed at operation showing the fistula between the femoral vessels. The large sac opened into the fistula (Army Medical Museum.)

pable posterior tibial and dorsalis pedis pulses. The blood pressure was 120 systolic and 78 diastolic. There was no shortness of breath on exertion and the electrocardiogram was within normal limits. The soldier was returned to duty.

Remarks

This patient illustrates the cardiac dilatation, early myocardial changes and the marked enlargement of the proximal vessels.

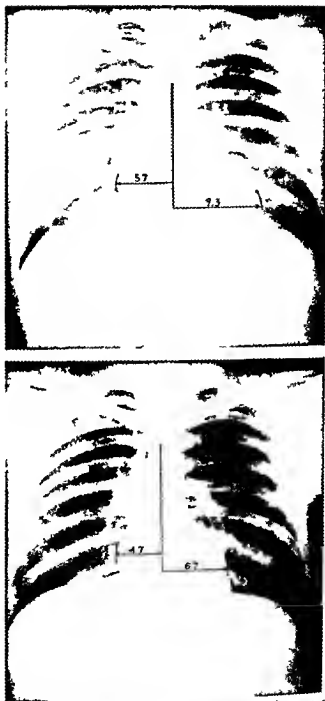


Fig. 463—Upper Teleoroentgenogram of the heart showing the cardiac dilatation present before operation. Lower Nineteen days after operation.

characteristic of large arteriovenous fistulas Holman believes these changes are caused by an increased blood volume incident to the arteriovenous communication The effects of excision of the fistula were notable the precordial pain subsided the heart returned to normal size and the myocardial changes shown by electrocardiogram disappeared

While the clinical findings before operation indicated an arteriovenous aneurysm a simple arterial aneurysm could not be excluded Even at operation when the thick walled sac overlying the vessels was isolated the differential diagnosis could not be made However, when the eddies of blood in the proximal vein were seen the diagnosis was certain

TREATMENT

The object of treatment is the eradication of the vicious fistulous tract in such a manner that it will not recur Many types of operative procedures have been described some of which have led to recurrence of the fistula and others to production of emboli or secondary hemorrhage Ligation of the proximal and distal artery the proximal and distal vein together with excision of the segment containing the fistula is the operation of choice This quadruple ligation with excision has given the most satisfactory results in the largest number of cases Operative procedures which restore the continuity of the artery either by transvenous suture or suture of the fistula, are often dangerous and usually unnecessary for the collateral circulation developed about these fistulas is sufficient to maintain peripheral circulation after quadruple ligation

In certain instances where large inaccessible collateral vessels enter the fistulous segment or where its firm adherence to surrounding structures makes excision hazardous it may be obliterated by mattress sutures after quadruple ligation as described by Reid

Emphasis must be given to the disastrous results following ligation of the proximal artery *alone* This must never be done for when the main arterial pressure is removed blood from the collateral arterial system will flow back through the fistula resulting in inevitable distal ischemia

The presence of an *adequate collateral circulation* must be the first consideration before operation Fortunately an arterio

venous fistula is a most powerful stimulus to the development of collateral vessels and if four to six months are allowed a satisfactory peripheral circulation can be expected. Occasionally because of rapid increase in the size of the sac secondary hemorrhage or progressive cardiac dilatation and failure early operation must be performed before adequate collateral circulation has been established. In such cases, sympathetic block of the extremity involved either by novocain injection or actual section as described by Gage should be obtained before operation.

Thoughtful attention to the type of anesthesia used is important. Continuous spinal procaine anesthesia is ideal for operations on the vessels of the lower extremities including the iliacs. For the upper extremity and neck cyclopropane oxygen or intratracheal ether have proved satisfactory.

In no surgical procedure is meticulous hemostasis, careful dissection and gentle handling of tissue more important. It is of advantage to work without a tourniquet because distended vessels are more easily identified than those collapsed (Holman). The tissues about the aneurysm contain many large collateral vessels which must be securely ligated. Bleeding from smaller vessels may be controlled by electrocoagulation. The technic of ligation of the large vascular trunks has been described by Reid. Essential nerves often accompany the involved vessels or are actually incorporated in the wall of the aneurysmal sac. They require accurate identification and certain protection.

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MODERN PULMONARY RESECTION IN WAR SURGERY*

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THE excision of irreparably diseased lung tissue is common in civil practice. There has been no opportunity, however, to employ modern methods of pulmonary resection in war until the present conflict. Although the application of fundamental surgical principles learned during World War I was largely responsible for the improvements in thoracic surgery more than ten years elapsed after the first world conflict before surgical extirpation of lung tissue was undertaken except in an occasional case. The lack of enthusiasm for these procedures can be explained by examining the mortality and morbidity rates which could be anticipated a few years ago when pulmonary resection was undertaken. In a survey of cases collected from leading thoracic clinics throughout the world in 1932 Ballon, Singer and Graham¹ found that the mortality of lobectomy for bronchiectasis was approximately 34 per cent. Moreover, only 47 per cent of the lucky survivors enjoyed entirely satisfactory results. These statistics were for bronchiectasis cases only and it is safe to assume that in the few instances in which lobectomy was performed for other lesions the death rate was probably even higher. During the next decade almost incredible improvements were made. Statistics from leading clinics in England and the United States reveal that the average mortality for lobectomy in bronchiectasis cases is about 5 per cent. In determining this figure reports of less than fifteen cases were rejected to eliminate inclusion of four or five successful operations that are of questionable statistical value and might influence surgeons to be too optimistic concerning the dangers of removing lung tissue.

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Several outstanding series can be cited. Churchill's² remarkable series of 133 cases of lobectomy for bronchiectasis with a 3 per cent mortality. Edwards³ of England reported 166 cases in 1939 with a 12 per cent mortality. It is noteworthy that there were only two deaths in his last sixty four cases. Alexander and Haight⁴ have performed eighty four lobectomies for bronchiectasis and other conditions with four operative deaths. Ochsner and DeBakey⁵ have had forty five lobectomy cases with three deaths. There were no deaths in their last twenty five consecutive cases. Graham⁶, Blades and Kent⁷, Overholt⁸ and others with large numbers of cases report operative mortalities of approximately 5 per cent. Combining all of the available reports of series of more than fifteen cases from the medical literature of the United States and England a total of 545 cases have been recorded with a mortality rate of 5.3 per cent. The great majority of patients have been operated on for bronchiectasis. However in some of the series pulmonary resections for other conditions were included.

No single factor accounts for these advances. The physiologic lessons learned in the first world war however furnished a basis for further developments. Outstanding among these was the contribution of Graham and Bell⁹ whose work eliminated most of the physiologic pandemonium by establishing the dangers associated with open pneumothorax. Practical methods for the control of intrapulmonic pressures when the chest is opened widely were soon perfected and precise operating replaced earlier slapdash methods. As a result of the combined clinical experiences and investigatory observations accumulated during the two decades following World War I operations in the thorax can now be undertaken with a comforting knowledge that the patient is exposed to little if any more danger than is associated with major operations elsewhere in the body. It is interesting that during the formative period of thoracic surgery before the specialty was dignified by chest surgery services in leading hospitals the Walter Reed General Hospital by necessity became a chest center. Immediately after the last war many of the victims of the influenza epidemic with chronic empyemas which had resulted from complications of the disease were sent here for treatment. The injudicious use of open drainage before the empyema was localized had often aggravated the condition. The

enormous experience with these cases accumulated by Colonel William Keller¹⁰ accounts for many of the clinical principles of modern thoracic surgery

Recent results with pulmonary surgery justify the conclusion that there should be no hesitation in recommending the excision of diseased lung tissue provided enough lung can be conserved to furnish adequate respiratory exchange and it is known that conservative measures will not cure the disease. Many patients who were handicapped by chronic cough productive of foul sputum or blood are cured and live normal lives after the diseased lung tissue is extirpated. Each year increasing numbers of cases of bronchiogenic tumors are being saved by surgery. The success with civilian patients suggests but does not prove the value of pulmonary resection in military surgery. The purpose of this clinic is to discuss some of the problems of lung surgery in patients in the military service and to comment on the selection of cases, the various methods now employed and finally the disposition of patients who have been subjected to pulmonary resections.

In war the preservation of man power is a paramount issue. Whether excision of lung tissue is feasible for members of the armed forces can therefore be determined by answering two questions: Will the majority of patients who have had lung tissue removed return to military duty? And is it possible to predict with reasonable accuracy which cases will be partially disabled by the operation?

These questions can we believe be answered by the results in fourteen consecutive cases treated by pulmonary resection at Walter Reed General Hospital.* Nine patients from this group have returned to military duty and it can be predicted confidently that the majority of the others now convalescing will soon return to their assignments. A total pneumonectomy for bronchiogenic carcinoma not included in the series was performed on a patient not on active duty and disqualified for other reasons than the pulmonary lesion. The lung and carcinoma

Since the preparation of this manuscript seven more patients have been subjected to pulmonary resection. In the entire series of twenty-one patients there has been one death which occurred eight weeks after the operation. The postoperative course in this case was complicated by the development of a bronchopleural fistula. The exact cause of death was not clear at post mortem examination.

were removed and the patient recovered fully. The operation in this case was undertaken as a life saving measure and not with the intention of returning the patient to military duty.

SELECTION OF CASES CLINICAL PROBLEMS TECHNIC

Certain administrative requirements must be fulfilled before any member of the armed forces can be subjected to an operation. It is obvious that particular care must be observed in meeting these regulations when a radical operation is contemplated. The problem from a clinical standpoint is straightforward. The risks of the operation should be balanced against the dangers of the untreated disease both from the standpoint of immediate threat to life and from progressive disability. It is our opinion however that in the selection of cases for elective pulmonary operations in patients in the military service another important factor must be determined namely Does the patient want to be a soldier? Operations on subjects who have no desire to serve would result in failure and cast disrepute on the treatment. With few exceptions however it has been our privilege to treat men whose principal interest has been to be cured and returned to duty. Varying amounts of lung tissue depending upon the extent of the disease have been removed. The selection and disposition of the cases and the clinical problems involved will be illustrated by the following case reports.

Case I Bronchiectasis Involving the Right Lower Right Middle and Antero Inferior Segments of the Right Lobe

A thirty three year old soldier complaining of a chronic cough productive of purulent sputum was admitted to the Walter Reed General Hospital two months after the onset of illness. The first manifestation of pulmonary disease was acute with chills fever and pain in the chest. The acute phase subsided after sulfonamide therapy but the chronic productive cough persisted. Complete clinical and laboratory investigations established the diagnosis of bronchiectasis involving the right lower right middle and antero inferior segments of the right upper lobe (Fig 464).

The patient's general physical condition was excellent. There were no contraindications to surgical intervention. Accordingly the right lower lobe and right middle lobe were removed and the antero inferior segment of the right upper lobe was resected by

partial lobectomy conserving the remainder of the undiseased upper lobe

Operation—An incision was made in the right thorax extending from the level of the fourth thoracic vertebra following the curve of the scapula and extending to the midaxillary line (as shown in Fig 465, of another patient) The underlying muscles were divided and the thoracic cage exposed The sixth rib was identified and almost the entire length of the rib resected subperiosteally (the level of the entrance into the pleura and



Fig 464—Lipiodol bronchogram showing extensive bronchiectasis of the right lung

whether a rib is resected and the incision made into the pleura through the rib bed or whether two ribs are divided and the incision carried through the intercostal space are details of technic of little importance and vary with individual surgeons) The underlying pleura was incised and the chest wall spread open with rib spreading retractors The gross appearance of the lower lobe was not unusual The right middle lobe was completely atelectatic The interlobar fissure between the right middle and right lower lobes was unusually complete The lower lobe was retracted laterally and the anterior surface of the lobe root

exposed. The pulmonary artery to the right lower lobe was identified and dissected free for a distance of about 2.5 cm. The branch to the dorsal division of the lower lobe was identified and divided between sutures. The mediastinal end of the vessel was doubly ligated with silk. The pulmonary artery to the basal division was dealt with in the same manner. The bronchus to the right lower lobe was then clamped and divided leaving the lobe attached by the inferior pulmonary vein. The vessel which had been exposed by dividing the pulmonary ligament was encircled

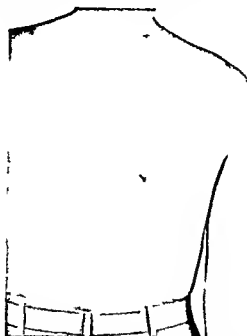


Fig. 465—Photograph of the usual necrosis for pulmonary resection.

With a silk suture and a small hemostat was placed distal to the suture. The lobe was amputated and a second silk tie placed around the vein.

The repair of the amputated bronchus was accomplished by placing two mattress sutures of fine steel wire through the bronchus to approximate its edges. These were reinforced by a few interrupted sutures of fine black silk. The bronchial stump was then covered with a free pleural graft. The middle lobe was mobilized and the fissure between the middle and upper lobe developed by incision of the lung tissue between clamps. The

hilum of the middle lobe was small. The lobe was amputated between clamps and secured with silk sutures which passed through the bronchus and also secured the blood vessels.

The antero-inferior segment of the right upper lobe was identified. The boundaries were distinct because the segment was partially atelectatic and when the lung was deflated and inflated, the segment filled poorly. The segment was resected between clamps (details of partial lobectomy are included in Case IV). At the completion of the operation 0.6 gm of sulfanilaz



Fig. 466—Postoperative x ray film. Note the space occupied by remainder of the right upper lobe.

mide was placed in the pleural space. The chest wall was closed first by approximating the fifth and seventh ribs by perichondral sutures, followed by reconstruction of the intercostal muscles. The muscles of the chest wall and the skin were closed in layers. Two catheters were inserted into the pleural cavity through separate stab wounds and connected to a continuous suction apparatus.

Bronchoscopy was performed immediately after the operation to remove retained secretions. The postoperative result is shown in Figure 466.

Comment—The bilobar distribution of the bronchial dilations in the lower and middle lobes in this case is common. In this connection it should be emphasized that bronchiectasis is not as formerly thought a disease which is usually confined to the lower lobes. During the past ten years in studies of potential surgical cases of bronchiectasis many reliable investigators have demonstrated that the disease usually affects at least two lobes. The most frequent distribution is in the left lower lobe and the lingula of the left upper lobe (left middle lobe). The combination of right lower and right middle lobe disease is second in frequency and is the most common of all right sided lesions.

Involvement of part of the upper lobe in addition to the usual bilobar disease complicated the problem. Total pneumonectomy would insure complete eradication of the disease but would necessitate the sacrifice of a large volume of undiseased functioning lung tissue. A partial upper lobe lobectomy with removal of the anterior inferior segment was therefore the preferable procedure provided the segment could be demonstrated accurately when the operation was performed. This proved to be the case. The soldier is now on duty.

Case II Bronchiectasis Involving the Left Lower Lobe and Lingula of the Left Upper Lobe

The second case which will be presented illustrates the most common localization of bronchiectasis namely the left lower lobe and lingula of the left upper lobe. For surgical purposes the lingula of the left upper lobe may be regarded as the left middle lobe and except for minor anatomic variations and embryonic differences the lingula of the left upper lobe is comparable in every respect to the right middle lobe. In more than 60 per cent of cases of lower lobe bronchiectasis involvement of the middle lobe on the corresponding side will be present. The lingula can be identified easily and its removal when the left lower lobe is extirpated does not appreciably increase the risk or technical difficulties of the operation.

A twenty eight year old soldier first became ill seven months before admission to the Walter Reed General Hospital. The initial illness was characterized by chills fever and chest pain. The acute phase of the disease gradually subsided but about two weeks after

its onset he suddenly found his mouth full of blood and coughed up a large amount of frothy bloody sputum. His general health and ability to engage in various activities improved but he continued to cough up large amounts of purulent material. The family history and past history were irrelevant. Physical examination and laboratory studies were not unusual. Lipiodol bronchograms revealed saccular bronchiectasis of the left lower lobe and lingula of the left upper lobe. Since this patient was in satisfactory general physical condition for operation and his length of service fulfilled administrative requirements, operation was advised. In addition to these factors it was the opinion of medical officers who examined him that he would be a valuable soldier provided the chronic cough could be relieved.

Operation—The left lower lobe and lingula of the left upper lobe were excised. The left lower lobe was removed by ligation of each structure at the root of the lobe. The method is essentially the same as described in Case I for removal of the right lower lobe. The technic advocated by Churchill and Belsey¹¹ was employed for lingulectomy. The bronchus and blood vessels of the lingula were exposed. The vessels were ligated and the bronchus occluded. Variations in the intrapulmonic pressure through the intratracheal catheter then created a delineating atelectasis of the segment. Excision of the lingula was accomplished between clamps.

The postoperative course was uneventful except for a superficial wound infection which healed promptly after drainage. The productive cough has entirely disappeared. He has gained weight and is considered fit for duty.

Comment—The importance of complete extirpation of bronchial dilations is obvious. There is no question that many of the failures of the surgical treatment of bronchiectasis have been the result of faulty preoperative localization and the erroneous conception that bronchiectasis is primarily a disease of the lower lobes. Failure to identify the lingula on the left and the right middle lower lobe is particularly common. Surgical localization of bronchiectasis prior to pulmonary resection cannot be accomplished satisfactorily by a single postero-anterior bronchogram since the bronchial divisions of the right middle lobe and the lingula of the left upper lobe overlap those of the corresponding lower lobe. To obtain the necessary three dimensional concept

of the thorax for recognition of the middle lobes it is necessary to utilize either the oblique projections or a combination of the

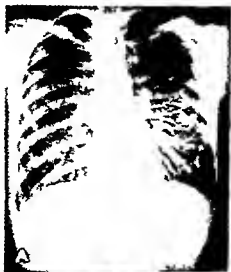


Fig 467—*A* Postero-anterior bronchogram. The bronchi overlap and precise localization of the bronchial dilatations is difficult. *B* Lateral view of chest. The anterior position of the lingula is demonstrated clearly. *C* The right anterior oblique projection of the bronchial tree demonstrating the lingula of the left upper lobe (left middle lobe).

postero-anterior and lateral projections to determine the exact localization of the disease (Fig 467 *A, B, C*).

Case III Bronchiectasis Involving the Right Middle Lobe

A twenty seven year old soldier was admitted to the hospital complaining of a chronic cough productive of purulent sputum of three months duration. Two weeks before his admission to the hospital he suffered an acute illness which was considered to be pneumonia localized in the right middle lobe. The acute features of the illness namely chills and fever subsided in about ten days however the chronic cough which had existed previously became worse and large amounts of foul smelling sputum were coughed up. A clinical and laboratory survey of the case revealed nothing unusual except



Fig. 468—Lipiodol bronchogram demonstrating bronchiectasis of right middle lobe

the pulmonary lesion. Lipiodol bronchograms established the diagnosis of saccular bronchiectasis of the right middle lobe (Fig. 468).

The middle lobe was extirpated on August 28, 1942. Following hospital convalescence and sick leave the officer returned to limited duty and was later reclassified and is now engaged in full active duty.

Comment—The operative technique employed in this case was similar to that described for middle lobe lobectomy in Case I except that the bronchus to the lobe was isolated and ligated.

separately. Of all the pulmonary lobes the right middle lobe is probably most adaptable to resection. It is usually easy to identify the structures at the hilum of the lobe and to ligate them separately.

Even when the tourniquet technic is employed the hilar stump is so small that complications resulting from the development of a bronchial fistula are unusual.

Case IV Bronchiectasis Involving the Posterior Medial Portion of the Left Lower Lobe Treated by Partial Lobectomy

A twenty three year old soldier was returned from overseas duty because of a chronic productive cough. The first indication of pulmonary disease was an acute illness in August of 1940 manifested

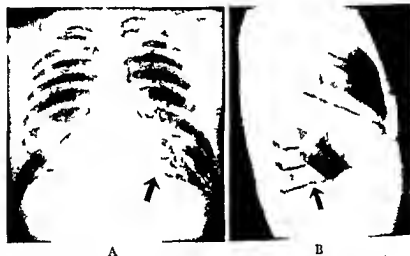


Fig. 469—A Lipiodol bronchogram showing a small zone of bronchiectasis in the left lower lobe. B Lateral x-ray film of chest. Note small calcifications in the posteromedial segment of the lower lobe.

by chills, fever, and cough. He was in a hospital a few days, treated with sulfonamide therapy, and shortly thereafter resumed full activity. His general level of health was good, and he was sent overseas where exposure and other hardships of the field duty caused the cough to become more severe and productive of about 6 ounces of thick sputum each day. Physical examination and laboratory investigations were not unusual except for a few rales at the left base posteriorly and the demonstration of a small zone of saccular bronchiectasis in the posterior medial portion of the left lower lobe. In the lateral projection on a conventional x-ray film, small

cavities could be seen in the same position as the saccular dilations demonstrated by the radiopaque oil (Fig 469 A, B)

Since all of the disease was confined to a single bronchial pulmonary segment and precise preoperative location of the lesion had been accomplished a partial lobectomy with excision of the posterior medial segment of the lower lobe was performed

Operation—The thorax was opened in the usual manner (see description of Case I) and careful inspection of the lung surface revealed a rudimentary fissure delineating the posterior medial segment. Inflation and deflation of the lung by rapid variations in the intratracheal pressure caused the boundaries of the seg-

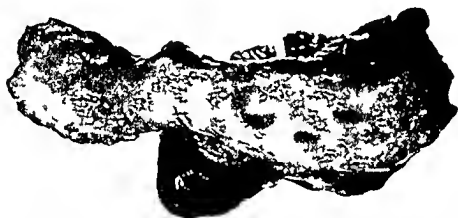


Fig 470—Photograph of posteromedial segment of the lower lobe after removal. The large bronchial dilations are apparent. The patient has had complete relief of symptoms.

ment to be even more apparent. Transillumination of the inflated lung revealed a relatively avascular line of cleavage between the posterior medial and posterior lateral segment and incision through the lung tissue was made at this level. The proximal portion of the segment was excised between clamps; all bleeding vessels were ligated and the cut surface of the lung parenchyma was covered with a free graft of parietal pleura which was obtained from the chest wall. It was possible to palpate the bronchial dilations in the segment and particular care was exercised to excise the lesion with a margin of healthy lung tissue (Fig 470). The remainder of the technical details are identical with those described in previous cases. The postoperative course was

satisfactory and it is anticipated that the patient will return to full duty.

Comment—Churchill and Belsey suggested in 1938¹¹ that despite the lack of well defined surface markings the bronchial pulmonary segments might replace the lobes as surgical units of the lung. They performed segmental pneumonectomy in resection of the lingula of the left upper lobe (left middle lobe) by removing the posterior medial segment of the lingula and also employed and advocated the technique in operations on the dorsal divisions of the lower lobe and elsewhere in selected cases. The principles of partial lobectomy by segmental resection to conserve important amounts of lung tissue become particularly important when subsequent strenuous activity is anticipated. Our experiences with patients in the military service have convinced us that in well localized peripheral lesions partial lobectomy should be employed.

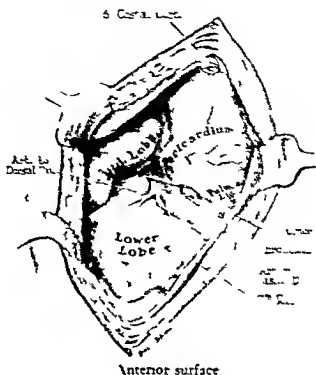
SELECTION OF OPERATION

No attempt will be made to discuss in detail the problems of operative surgery when the various types of pulmonary resection are undertaken. The methods will vary depending upon the volume of lung tissue to be eradicated, the nature of the lesion and the particular circumstances in each case.

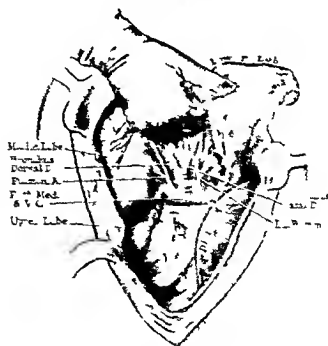
Although removal of an entire lung (total pneumonectomy) was first performed by the tourniquet technique the operation is now usually accomplished by identification and separate ligation of each structure at the pulmonary hilum. This method was first introduced by Rienhoff¹, Mason¹², Crafoord¹⁴ and others and has now been generally adopted. It is safe to conclude that tourniquet amputation of a lung is to be condemned in the treatment of pulmonary tumors and should be avoided at all times except under unusual circumstances which preclude individual ligation technique.

Partial pneumonectomy may involve the removal of one or more lobes or the excision of all or part of one or more bronchopulmonary segments. The excision of a pulmonary lobe demarcated by more or less constant fissures has been illustrated in Cases II and III and the operative technique described. Partial lobectomy by segmental resection is described in Case IV.

The chief advantage of individual ligation of each anatomic



Anterior surface



Posterior surface

FIG. 41.—Diagrammatic sketches of the anterior and posterior surface of the hilum of the right lung, showing the position of the important structures which must be determined when lobectomy is performed.

structure when either total pneumonectomy or lobectomy is performed has been the marked increase in successful closures of the bronchi and the prevention of the severe infections of the pleura which accompany bronchial fistulas. It should be emphasized however that occasions will arise when induration about the lung root will prevent the identification and isolation of the vessels and bronchi. In these cases the tourniquet technique should be employed. It should also be noted that the sequence of the dissection may be varied depending upon the conditions encountered in each case. Primary ligation of the pulmonary vein affords protection against emboli; however it is often difficult to isolate the vein first. By rotating the lung or lobe to visualize both the anterior and posterior surfaces of the lung root the various structures can be exposed and divided. The order of dissection can only be determined after the various structures are identified and the induration, adhesions and the position of enlarged lymph nodes are evaluated (see Fig. 471).

POSTOPERATIVE CARE

The postoperative care of pulmonary resection cases begins in the operating room as the chest is being closed and must not be relaxed until the lung is completely re-expanded, the wound healed and the patient fit for discharge. In addition to general principles of combating shock, maintenance of body fluids and so forth, the thoracic surgeon must concern himself with the re-expansion of the remaining pulmonary tissue. Inflation of the lung through the intratracheal catheter and anesthetic apparatus as the chest is being closed is the first essential step in effecting pulmonary re-expansion. Before the effects of the anesthetic agent have subsided, postoperative bronchoscopy should be performed routinely to remove secretions which have accumulated in the tracheobronchial tree during the operation.

As soon as the patient awakes and blood pressure and pulse are stable, the head of the bed is elevated to a 30 to 45 degree angle to keep fluid which may have accumulated in the pleural cavity in a dependent position allowing the catheter drainage to function effectively. One or two catheters may be employed depending upon the size of the cavity and its position. A negative pressure of from 9 to 12 cm. of water is maintained until re-expansion of the lung is complete. Under ideal circumstances

this should be accomplished in twenty four to forty eight hours (Fig 472) When a complicating empyema is anticipated, the drainage tube or tubes as the case may be, are left in place The caliber of the tubes may also be varied depending upon the amount of infection in the lung and contamination of the pleura during the performance of the operation

Postoperative administration of oxygen, either through a nasal catheter or an oxygen tent is routine and should be continued for two or three days During this period coughing must be



Fig 477—Postoperative x ray film of chest twenty four hours after lower lobe lobectomy showing re-expansion of remaining lung tissue

encouraged Temporary manual immobilization of the chest wall by exerting pressure on the lower costal region with the hands will allow coughing without undue pain and insures added protection against the accumulation of fluids in the airways

Pain in the chest is the principal complaint expressed by most patients and constitutes the most important reason for suppression of the cough reflex It is our opinion therefore, that morphine should be given in sufficient amounts to provide comfort provided the patient is made to cough at regular intervals

Transfusions of blood administration of plasma and other generally accepted measures are employed to combat shock.

ANESTHESIA

The anesthetic technique for intrathoracic operations should furnish first and most important a practical means for controlling intrapulmonic pressures and second facilities for aspirating the respiratory passages during the performance of the operation. A tight fitting face mask will probably furnish adequate control of intrapulmonic pressure but fails to provide a means for intermittent aspiration of mucus pus or blood which may collect in the tracheobronchial tree during the operative procedure. The principal consideration in the choice of the anesthetic agent is that it must be a gas which can be administered with a high concentration of oxygen. Cyclopropine gas and ether vapor both fulfill this requirement. In our own clinic the choice between the two agents is made by members of the anesthetic department headed by Major Harold Bishop and depends upon the anesthetic problems peculiar to each case.

It is our opinion that the use of spinal analgesia peridural anesthesia and local field block for intrathoracic procedures is to be thoroughly condemned. Although it is admitted that patients with sufficiently large vital capacities may tolerate open thoracotomy without protection of controlled intrapulmonic pressures the deliberate use of methods which fail to provide this added protection is difficult to understand.

SUMMARY

Of fourteen members of the armed forces who have been subjected to pulmonary resection nine have returned to duty. Varying amounts of lung tissue have been extirpated depending upon the size and nature of the lesion. It is anticipated that the majority of patients now convalescing from operations on the lung will be able to resume their former activities.

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CONTINUOUS CAUDAL ANESTHESIA*

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AN increasing number of articles have appeared in the literature during the past year on an anesthetic method which has been designated by Hingson and Edwards^{2 3 4} as continuous caudal anesthesia. These physicians administered their first continuous caudal anesthetic on January 6, 1942. They concluded in one of their early articles that this method, applied to obstetrics, presents a safe and effective method for relieving the pain of labor and delivery and that it also has possibilities as a method of anesthesia for certain surgical operations. Contributions toward a further development of this anesthetic method have been made by Adams, Lundy, and Seldon¹ by Siever and Mousel⁵ and by Gready and Hesseltine.⁶ All are agreed that there are certain advantages and disadvantages associated with the procedure, which is still in a formative stage. Further details related to its technic must be worked out.

This form of anesthetic production has been practiced at Walter Reed General Hospital during the past year in a small group of obstetrical and surgical patients. The first patient was injected by this intermittent method on July 13, 1942. Since that time a total of eighty-eight patients have received continuous caudal anesthesia. Eighty-two of these have been obstetrical patients in labor; four surgical patients have received it as a means of producing lumbar sympathetic block; and two surgical patients received this anesthetic for operations upon the lower extremities. Two previously described methods have been employed in continuous caudal anesthesia: (1) the needle method of Hingson and (2) the catheter method which has been described by Adams, Lundy, and Seldon. The catheter method has been used seventy-nine times and the needle method in nine cases.

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CONTINUOUS CAUDAL ANESTHESIA IN OBSTETRICS

The eighty two obstetrical patients receiving this form of anesthesia included seventy one primiparas and eleven multiparas. The ages of this group varied from seventeen years to thirty eight years with the average being twenty five. Episiotomy, low forceps and repair were routinely employed in this entire group providing an exacting test upon the anesthetic used. Either morphine and scopolamine or nembutal or both were administered usually in the first stage of labor in forty three of these cases. In thirty nine cases these drugs were not used and in those instances in which they were employed it was not the practice to repeat their administration.

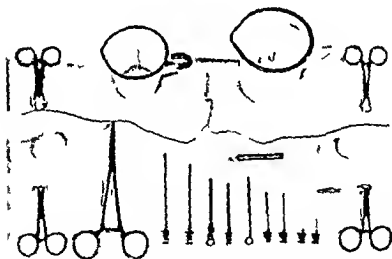


Fig 473—Tray used in continuous caudal anesthesia showing a full set of needles for the catheter method graduated and a laparoscope

Technic

Catheter Method—The patient is placed in the knee chest position with the buttocks brought well over to the side of the labor bed. The skin of the sacral area is cleansed with ether followed by antiseptic. A wheal is raised in the center of the sacral hiatus which if not readily palpable is to be found approximately $1\frac{1}{2}$ inches above the tip of the coccyx. The sac

rococcygeal ligament is pierced with a 20 gauge $1\frac{1}{2}$ inch (in travenous) needle and 5 cc of anesthetic solution is deposited in the sacral canal. If a No 5 ureteral catheter is to be used a 13 gauge 2 inch needle with stilet works very satisfactorily for the introduction of the catheter. However a little longer needle (3 inch) if available is preferable. This large needle is introduced with the bevel up until the anterior sacral wall is encountered, is rotated 180 degrees and then slid upward into sacral canal with bevel down until posterior wall is reached. Stilet is removed and needle is observed for possible escape of spinal fluid. For further check on position of needle in relation to dura a syringe may be attached and aspiration carried out. A No 5 ureteral catheter (Fig 474) is tested for patency and



Fig 474—Showing two sizes of ureteral catheters. No 13 needles used to introduce catheters and the various parts of the Hingson apparatus disassembled. (Note catheter on the left which was broken 1 cm from its tip on attempted withdrawal through a No 13 needle.)

possibility of any circular cracks or flaws. It is threaded through the heavy needle for a distance of 12 cm. the outer needle is removed and the catheter is anchored tightly in its position by means of narrow adhesive. The end of the catheter is enclosed with sterile gauze and 25 cc of anesthetic solution is injected through the catheter by means of a 10 cc syringe and a 22 gauge 1 inch needle. The patient is permitted to lie in any position desired when the catheter method is used. A graduate containing the anesthetic solution, a syringe and a 22 gauge needle is kept sterile on a bedside table. Subsequent injections are carried out approximately every hour with 20 cc of the anesthetic solution. If the Hingson apparatus (Figs 474-475) is available it can be connected directly to the catheter as well as to an indwelling needle (if such method is used). A 250-cc

discarded plasma bottle serves as an excellent container for the anesthetic solution. A ureteral adapter serves as a connector between the ureteral catheter and the small bore tubing of Hingson's apparatus. In such manner a constant connection can be maintained between syringe and catheter, future injections are simplified and maintenance of sterility can be more easily carried out.

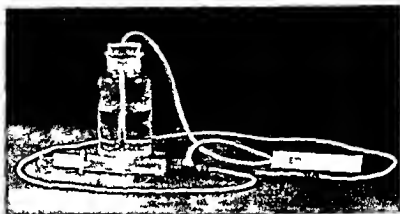


Fig. 475—Hingson apparatus shown with ureteral adapter. It can be used to connect the apparatus to a No. 5 ureteral catheter.

Needle Method—A malleable needle designed for continuous caudal use has been manufactured which is inserted into the sacral canal and then connected to the Hingson apparatus. This needle is made of hyperchrome steel, has an extra outlet hole and is reinforced at the hub, thereby diminishing the possibility of breakage at this point. If this method is chosen, the patient is instructed to lie on her side throughout the anesthetic period.

Anesthetic Agents and Dosages

Metycaine was used in sixty-seven of these cases, procaine in ten, and intracain in five. A 1.5 per cent solution of these drugs was made up in forty-four of the cases and a 1 per cent solution in thirty-eight. It was found in those cases in which 1 per cent was used that more solution was required for the anesthetic period. Vasoconstrictor drugs such as epinephrine (1:100,000) or cobefrin (1:40,000) were used in thirty-three cases but it was felt that the anesthetic periods following their injection were

not prolonged sufficiently to justify their use. In forty-nine cases no vasoconstrictor was used.

The average amount of anesthetic drugs used in the eighty-two cases was 138 cc. The smallest dosage was 25 cc. and the largest dosage was 633 cc. (metycaine, 1 per cent or 6 gm). In two other instances dosages were 99 cc. and 120 cc., but these amounts were used in complicated and prolonged labors. In those cases in which large dosages of anesthetic drugs were administered over long periods the results were much less satisfactory. The initial injection was repeated on an average of 7.5 times in the eighty-two cases. The number of injections ranged from a single injection to eighteen.

Duration of Anesthetic Periods and of Labor

One patient was carried for a period of twenty-four hours under continuous caudal anesthesia. The shortest duration of anesthesia was one hour. For all cases the average duration was four and one-half hours.

The average duration of labor for the entire series was twenty hours. The shortest labor was five hours and the longest was eighty-four hours. Four long labors were encountered in the group. In such cases after reinjections were carried out over a period of ten to twelve hours, less relief would be obtained on each subsequent injection.

Depth of Catheter Insertion

The catheter was inserted to depths varying from 4 cm. to 23 cm. In the beginning of the series it was felt that it was necessary to insert the catheter for a depth of 15 cm. or more (Fig. 76) to obtain complete relief from pain. Catheters were inserted for depths of 15 cm., 17 cm., 18 cm., and up to 23 cm. in a group of fourteen patients injected early in the series. Out of this group two patients developed complications which will be described later in detail. For the remainder of the series the catheter was inserted to a depth of less than 15 cm. Depths of 4 cm., 8 cm., 11 cm., 12 cm., 13 cm., were all used and it was found that results were just as good as in those cases in which greater depth of insertion had been used. At the present time the catheter is being inserted 12 cm. It may be found that this can be reduced still further with just as effective results.



Fig. 476—X-ray showing No. 5 ureteral catheter inserted for drainage of 15 cm. of the bladder and outlined by pyelopaque. Note breech presentation.

Anesthetic Results

Some degree of anesthesia developed in all cases in which this method was used. However, complete freedom from labor pain and complete anesthesia for delivery were not accomplished in all cases. In fifty eight cases (or 70 per cent) we were completely satisfied with the results. In twenty four cases (or 30 per cent) complete anesthesia was not achieved although the results cannot be put down as unsatisfactory. Some of the factors encountered in this latter group will be enumerated. Three long labors were encountered and as has been stated after ten or twelve hours of anesthesia reduced relief from pain resulted on each succeeding injection. These patients required supplementation for delivery. In three patients the catheter either slipped out or became disconnected. In one instance the catheter became plugged and in one instance the needle became plugged. In

one case the catheter became contaminated and anesthesia was discontinued for this reason. There was unilateral anesthesia, only, in two patients. Occasionally there would be complete obliteration of labor pains but not sufficient anesthesia for episiotomy, low forceps and repair. The incidence of all of these technical difficulties was reduced as experience was gained in the management of a greater number of cases.

Low Incidence of Untoward Effects

There is no doubt but that this method of obstetrical anesthesia carries a low incidence of harmful effects upon mother and baby. Definite complications can be explained by errors in technic. It is gratifying to have available a method of obstetrical anesthesia which practically eliminates the need for resuscitation of the baby. In no instance throughout these eighty-two deliveries has it been necessary to resuscitate the baby. We believe this to be an outstanding advantage of the method and feel that it has not been emphasized sufficiently in the literature.

There was a mild episode of vomiting with three patients. In only one case was there any more than normal blood loss associated with delivery and in this one instance there was a low position of the placenta. It was the opinion of the attending obstetrician that there was no increased frequency of postpartum catheterization. There was no infection in any of the cases at the sites of needle or catheter insertion.

There has been speculation concerning the possibility that continuous caudal anesthesia may slow the course of labor. This cannot be borne out in this series although in those instances where a high level of anesthesia developed by error there is no doubt that the anesthetic played a part in prolonging labor. If for any reason it is felt that labor may be prolonged, continuous caudal anesthesia should be delayed until labor is well advanced or used as an anesthetic for delivery only.

Complications

We would like to record three complications which were encountered in this small series. All were due to errors in technic.

1 *Neurological Sequelae*—This patient was a primipara thirty-four years of age who delivered by breech extraction a

normal baby after a prolonged and difficult labor of forty three hours. Caudal anesthesia was maintained for a period of twenty four hours but was discontinued owing to the development of anesthesia high on the trunk, severe pain on injection, drowsiness and because of the fact that the patient received decreasing effect from succeeding injections. A right facial weakness and paresis of the right arm became apparent shortly after the occurrence of the above symptoms. The delivery was complicated by vomiting and the patient developed a temperature elevation to 102° F. This patient had received 520 cc. of anesthetic solution through a catheter that had been inserted to a depth of 20 cm. It was felt that the catheter had been inserted to an excessive depth and that this accounted for many of these symptoms although the possibility of a dural puncture and subdural injections could not be definitely excluded. The right sided motor weakness cleared up gradually following the patient's discharge from the hospital. Following this complication catheter insertions have been kept to a maximum of 14 cm.

2 *Vascular Collapse*—This patient experienced tachycardia, blood pressure depression, numbness over the left chest and pain in the back of the neck following administration of caudal anesthesia. The catheter had been inserted to a depth of 18 cm. Following notation of the above symptoms the catheter was withdrawn to the 10 cm mark. However, unilateral anesthesia persisted. It was likewise felt in this case that the catheter had been inserted to an excessive depth.

3 *Broken Catheter*—This patient was obese with a fat pad lying over the sacrum. Attempted insertion of caudal needle and catheter was difficult. Removal of the catheter out through the needle was attempted but the catheter was sheared off at the end of the needle. Surgical removal of the caudal section of catheter was necessary. A catheter was broken off in an identical manner during an attempt to induce continuous caudal anesthesia for vasodilatation of an extremity. Following the experience in these two cases it became apparent that needle and catheter should be removed together as one piece when difficulty is encountered and in no circumstance should the catheter be pulled back through the needle.

Optimum Time for Administration of Anesthetic

One of the difficulties associated with this anesthetic measure is the determination of the optimum time for starting the procedure. Of course, endeavor was always made to obliterate pain for as many hours of the labor period as possible. However, it became apparent that our least successful cases were those in which the anesthetic was started many hours in advance of delivery. In such cases a tolerance seemed to be built up. In the prolonged labors, pain relief would be less complete and the patient would require a larger quantity of drug at more frequent intervals. In the beginning of this series the anesthetic was probably being started too early in the course of labor and the tendency now has been to delay more and more the initial injection of the anesthetic solution. Best results were obtained when the anesthetic was administered four to five hours prior to delivery. In other words, anesthesia was delayed until contractions were occurring regularly every three to five minutes and the patient was in definite need of some type of analgesia.

Sympathetic Block for Vasodilatation

It has been noted that accompanying the effects of continuous caudal anesthesia there is vasodilatation of the superficial vessels and increased skin temperature of the lower extremities. These effects denoting block of lumbar sympathetics were usually as pronounced as when lumbar sympathetic block is carried out by the customary paravertebral injections. Accordingly, continuous caudal injections were carried out on four patients for the purpose of vasodilatation by sympathetic block. Two of these patients were suffering from gangrene of an extremity secondary to embolism. In one of these continuous caudal injections were combined with refrigeration therapy applied to the extremities. The other two patients had thrombophlebitis of a lower extremity. Thermocouple readings were taken before and after injections and skin temperature elevations were recorded in all instances. When used for such purpose injections were made every two to three hours. In such fashion the lumbar sympathetics were bathed continually in the solution and a more constant sympathetic block could be accomplished than if paravertebral injections are repeated once or twice.

TABULATION

MORTALITY FIGURES TAKEN FROM LT COL. W. C. WILSON'S REPORT ON BURNS
IN THE MIDDLE EAST FORCES

Extent	Approximate Percentage	Mortality Per Cent
Very small	Under 5	0
Small	5-10	0
Small to moderate	10-15	8
Moderate	15-20	4
Moderate to extensive	20-75	60
Extensive	25-50	91
Very extensive	Over 50	100

GENERAL TREATMENT

The general treatment of burns is by now becoming pretty well standardized and the principles and practices involved in war burns are essentially similar to those sustained in civil life.

Relief of Pain

Relief of pain both during debridement and at other times should be attained by adequate doses of morphine given subcutaneously or intravenously. General anesthesia should seldom if ever be necessary.

Control of Hemoconcentration and Burn Shock

Control of hemoconcentration and burn shock requires vigorous *plasma substitution therapy* during the exudative phase of from forty-eight to ninety-six hours. During this time the degree of hemoconcentration is followed by means of the red cell count, hemoglobin and hematocrit determinations and urinary output. If facilities are available an occasional check should be made of plasma proteins, chlorides and nonprotein nitrogen. Given a severe burn involving 20 per cent or more of the body surface it is well to administer rapidly by vein an initial 500 cc of plasma for each 10 per cent of involved body surface and thereafter to be guided by one of the following simple calculations.

I. Method of Black based upon the hemoglobin reading

Plasma in liters required will be $\frac{5-500}{\text{Hgb}}$ (in per cent)

2 Method of Harkins, using the hematocrit

Plasma required will be 100 cc for every point above the normal (45 per cent)

3 Our method adapted from Harkins based upon the red cell count

Plasma required will be 100 cc for each 2 per cent rise in the red cell count above 5 000 000

Vigorous application of *heat* to patients already on the verge of shock is to be condemned, since by producing peripheral vasodilatation and fluid loss through perspiration it increases the tendency to shock. In short, the temperature should not exceed 80° F

The use of *adrenal cortical extract* (cortin) in experimental animals has been found by Rhoads Wolff and Lee to lessen the abnormal capillary permeability in burns. In treated animals less plasma was required to restore the circulating volume than in controls. We have had no opportunity to use cortin. Our experience with the synthetic hormone desoxycorticosterone acetate, in a few cases has not been conclusive.

Depletion and Anemia

Depletion and anemia although only mildly manifested in any but the deepest second degree burns becomes a serious problem in extensive third degree wounds during the sloughing stage when the necrotic corium is separating away and until sl in grafting is completed. This is especially true if sepsis is more than minimal and if exudation is profuse. During these late stages the patients lose appetite and weight and develop secondary anemia. Their blood chemistry studies show abnormally low plasma proteins especially of the albumin fraction. A high caloric intake, such as that prescribed by Lyons³ for chronically depleted soldiers with infected compound fractures should be striven for by a resourceful dietitian. The *diet* consists of 400 gm of carbohydrate 125 gm of protein and 75 gm of fat totaling 2775 calories. If the patient will tolerate it extra protein should be given since this is all important both in protecting the liver and in combating the negative nitrogen balance. Since there is a natural tendency in chronic sepsis toward fatty liver

the fats should be kept low. The following *vitamin intake* should be assured: 10 000 to 15 000 international units of vitamin A, 2 to 5 mg of vitamin B₁, 3 to 5 mg of vitamin B₆, 30 to 50 mg of nicotinic acid and 75 to 100 mg of vitamin C. Also if tolerated *ferrous iron* should be supplied for hemoglobin regeneration.

Almost inevitably it will be necessary in extensively burned soldiers to supplement the above with *parenteral protein alimentation*. There are drawbacks to the use of plasma and whole blood in this capacity. In the first place 1000 cc of blood or its equivalent 500 cc of plasma would supply only 35 gm of protein. Further as pointed out by Elman⁴ plasma is able to correct directly only hypoproteinemia. To regenerate tissue proteins its colloids must undergo hydrolysis and the component amino acids must then be resynthesized to the various tissue structures. In seriously debilitated patients this process may occur slowly if at all. It is now possible however to supply these building stones for protein synthesis in the form of a solution of hydrolysate of casein developed by Elman⁵ and others. It is doubtful whether whole blood is any longer necessary to correct the anemia. From the work of Whipple⁶ it appears that if adequate iron is available and protein is supplied as plasma amino acid or protein digest solution 2 to 4 gm of hemoglobin are formed for every gram of plasma protein.

Infection

Both the British and American armies now recommend general rather than local sulfonamide therapy both prophylactically and therapeutically. There is increasing evidence that adequate oral intake with the blood level in the vicinity of 10 mg per 100 cc is a more effective manner of combating wound infection than local application of the drug. Circular Letter No. 15 January 11 1943 from the Surgeon General's Office recommends that a dose of 4 gm preferably of sulfadiazine be administered initially. Then until diuresis is again established 0.5 gm doses should be given at four hour intervals thereafter the dosage should be increased to 1 gm doses every four hours for as long as the responsible medical officer considers necessary.

Penicillin⁷ is now known to be capable of ridding a majority of wounds of staphylococcus and streptococcus as well as the

gas forming anaerobes and certain other bacteria. It has so far demonstrated no serious toxic effects and practically no reactions of any sort. Clinical investigation is now in progress to determine optimum dosage and route of administration and to define its field of usefulness. At the same time the output of penicillin is being rapidly expanded with the prospect that soon there will be a sufficient supply for general use. There is reason to believe that this new agent will supplant the sulfonamides in the control of infection both in burns and in other wounds.

Prophylaxis against tetanus should be carried out in all but the most superficial burns by the customary injection of 1 cc. of tetanus toxoid. Except in extremely deep burns with destruction of muscle or shattering of bones, immunization against gas forming anaerobes is unnecessary.

LOCAL TREATMENT

The local treatment of war burns in contrast to their general treatment has been in a state of flux and of trial and error during the present war. One has but to glance through the report of Colonel Wilson¹ concerning the variety of treatments tried upon the burn casualties of the British Eighth Army or at Colonel Logie's account² of the practical problems involved in the treatment of burns at Tobruk to realize first that as yet no ideal treatment has been devised and second that warfare imposes many obstacles not met with in a civil community. Some of the main obstacles are frequently associated serious wounds, the problem of transport and the delay between receipt of burn and its definitive treatment, the scarcity of even such taken for granted facilities as water, the omnipresence of fine sand and dust in desert theaters and last but not least insufficient officer and nursing personnel.

Penicillin promises to be the outstanding contribution to local burn treatment in every phase but the emergency dressing.* Colebrook and co-workers³ found that by the use of a water soluble penicillin ointment containing 120 units to the gram fifty-four burns were rid of staphylococci and streptococci by the seventh or eighth day and in 76 per cent of the cases by the third to the fifth day. Among these were seven sulfonamides.

* At present at least since it is unstable at room temperature in ointments or solutions, it would not be feasible to use it in advance stations.

mide resistant burns Dressings were changed only at forty eight hour intervals Penicillin has no effect upon the gram negative bacilli *B proteus* *B pycyanus* and *B coli* However a new agent *streptothricin*,¹⁰ shows promise in this direction and is at the present time under study Streptothricin is the by product of one of the nonpathogenic soil actinomyces We propose in the next burn cases received to apply penicillin ointment locally and also to inject moderate doses parenterally

Greater attention should be given to the possibility of primary excision of selected third degree burns and immediate split thickness grafting This procedure has been advocated by Young¹¹ and others and was recommended in the Circular Letter No 15 The possibility of wound sterilization by penicillin should greatly increase the time limit and scope of this procedure

The *compressive type of dressing* for burns as now recommended by the Army seems greatly superior to any leatherizing method of treatment and its advantages are wholly aside from the favorite local application of the surgeon in charge By the resilient compression further loss of plasma is greatly lessened¹² At the same time the wound is well protected from further infection and the patient is allowed relative freedom of movement The local care of the burn is reduced to a minimum for the first ten to fourteen days during which time the dressing is left undisturbed During the sloughing period furthermore there is no tough eschar to be removed in addition to the necrotic corium and there is far less tendency for pockets of infection to develop

It was found by the British in North Africa that oral sulfonamide therapy combined with the tannic acid and silver nitrate local treatment carried with it a mortality of 60 per cent Consequently tannic acid and silver nitrate treatment has been abandoned by the British

Outline of a Workable Plan of Treatment for a War Burn Casualty

1 *First Aid*—The first principle in first aid treatment of burns is to keep the wound relatively sterile when first received as bacteria free as possible especially from nasopharyngeal organisms The patient and his attendants if masks are not available should keep their mouths shut as much as possible

The necessity of a first aid or makeshift dressing which must tide the soldier over for many hours during which time he may

have to undergo long and arduous transit is one of the chief problems of military surgery and one seldom met with in civil life. Furthermore, adapting this initial dressing to the later definitive one gives rise to further perplexity. Circular Letter No 15 recommends that the burned surface be covered with boric acid ointment or vaseline and over this a layer of fine mesh gauze and an outer dressing. Reliance is placed on oral sulfonamide for prophylaxis against infection. Obviously no debridement is possible on the spot. Now when the casualty arrives at the rear we must decide either to leave the original dressing in place or that the degree of contamination demands debridement under standard operating room technic. In the latter event all the previously smeared on vaseline or boric ointment must first be removed with whatever detergent is available adding greatly to the length and severity of the procedure.

2 *Initial Definitive Treatment*—This is understood well enough by now not to require further discussion. The chief problem is whether or not to debride the burn of the fresh arrival with his emergency dressing in place. For reasons already mentioned we favor the compressive type of treatment rather than the alternative tannic acid silver nitrate method.

3 *Technic of Dressings*—Certain measures should be insisted upon to avoid fresh contamination of the wound after removal of the initial compression dressing. Dressings should be changed either before or at least one hour after the beds are made and the wards are mopped out each morning. The patient, as well as the dressers, should mask and if sterile gowns and gloves are not available at least a 'knife and fork' technic with sterile instruments should be used.

Until penicillin ointment becomes available there is no local dressing outstanding enough to warrant especial emphasis. Dalin's packs, sulfonamide ointments, cod liver oil, boric acid ointment, saline packs and still others all have their adherents.

4 *The Sloughing Stage*—This trying period inevitable to all third degree burns, can be expedited somewhat by repeated gentle dissecting away of all detachable nonviable tissue. During this period we have combined mechanical cleansing with physical therapy by means of general tubbing for extensive trunk burns and the whirlpool bath for extremity burns especially those of the hands. Voluntary motions and exercises are much

more readily performed by the patient under the soothing influence of the warm bath. We have not found any notable advantage in hypertonic saline over simple tap water for these baths. Needless to say these facilities will not be available in many Army hospitals. Until now we have been gratified by the results of the whirlpool bath on our deeply burned hands in spite of any slight cross contamination that it might occasion. How well this will adapt itself to the new era of wound sterility penicillin and streptothricin seem to promise remains to be seen.

Interestingly enough in this series the burned hands with extensor surface involvement spontaneously assumed the position of function which is correct in these cases. When the flexor surfaces of the hands are involved the hands should be maintained in hyperextension.

5 Skin Grafting—For third degree burns, skin grafting should be carried out at the earliest possible moment. The more luxuriant the granulation tissue becomes the greater the amount of resulting scar tissue. Therefore as soon as the slough has separated and before the underlying granulations have time to develop a preliminary grafting should be done. A film of skin not over 0.005 inch (thin Thiersch) should be taken either by dermatome or razor and applied either in sheets or cut into small squares and applied as a mosaic. Once healing has occurred where necessary the scarred tissue may be excised and a deep intermediate thickness dermatome graft applied to a sterile field. The skin grafting in these cases was performed by Lieutenant Colonel Schuessler of the plastic surgery division.

6 Rehabilitation—Final rehabilitation is one of the most difficult and trying problems especially when the hands are involved. Early physical therapy followed as soon as possible by occupational therapy is desirable. The patient should constantly be urged to exert every effort in active motions as for example repeatedly gripping a rubber ball. Corrective splints so devised as to apply elastic traction against contractures should be worn at night. Numerous ingenious appliances were constructed by Sergeant Keith in the hospital orthopedic shop.

Where tendons especially the extensors have been destroyed free tendon transplants may at times be worth attempting.

CASE REPORTS

CASE I—Corporal P J D aged twenty eight years was aboard the transport U S S Tasker H Bliss when it was torpedoed. The ensuing blast prompted the soldier involuntarily to throw his hands

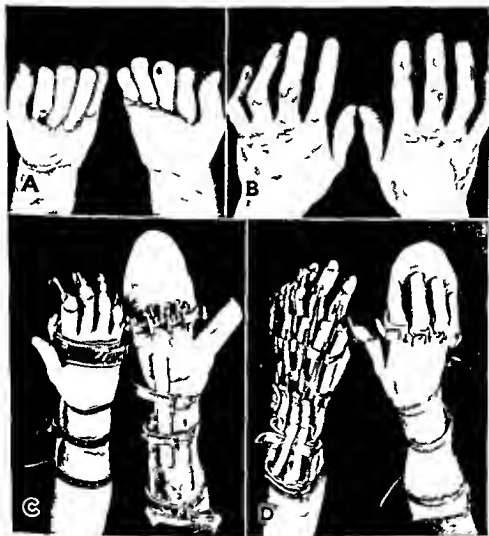


Fig 477 (Case I)—A B 195th day Showing flexion deformity C D With splints in place. The joints are not ankylosed therefore further improvement can be hoped for

over his eyes for protection resulting in flash burns of the hands face thighs and upper back. He escaped through a porthole into the sea from which he was rescued after immersion for thirty minutes. When rescued he lost consciousness for three days due to the

extreme degree of shock present, although he had experienced no pain

One unit (250 cc) of plasma was given three times daily for four days until the patient was clearly beyond the shock stage. The burned areas were dressed with a sulfonamide ointment until the soldier arrived at Walter Reed Hospital sixteen days from the time of burn. It was estimated that 25 per cent of the body surface was involved in second degree burn while there was third degree involvement of the extensor surfaces of both hands over the proximal phalanges and most of the dorsum of the left hand. The tendons were exposed over five joints in the left hand and over one joint in the right (initial photographs regrettably lost). The burns were cleansed with warm tap water and dressed with gauze strips impregnated with 5 per cent aqueous emulsion of sulfadiazine. Five hundred cubic centimeters of whole blood was given.

By the twenty fourth day all second degree burns had healed and granulation was progressing on the hands. Pulmonary embolism developed on the twenty first day, secondarily to a thrombophlebitis of the left femoral vein. On this account physical therapy and whirlpool baths were delayed until the eighth week. By twenty four weeks maximum improvement had been gained through physical and occupational therapy but a flexion deformity of the right third and left third and fourth fingers still existed (Fig 477 A B). An orthopedic appliance to stretch these fingers into extension was made (Fig 477 C D) and worn in bed at night. This has further increased function of the fingers. Free transplant repair of several of the extensor tendons is contemplated.

CASE II—Private H. R. aged thirty three years received flash burns of the knees, face and hands at the same time as the patient of Case I. This soldier suffered 4 per cent second degree and 3 per cent third degree burns. The extensor surfaces of the hands received deep third degree damage and were very painful. This patient also suffered immersion after escape through a porthole but was rescued and received treatment within forty five minutes. The hands were splinted and sprayed with tannic acid while a sulfonamide ointment was applied to the face and knees. In the absence of shock plasma therapy was not necessary.

All burned areas were redressed with sulfonamide ointments every fourth day until the patient's arrival at Walter Reed Hospital sixteen days from the time of injury. At this time the second degree burns were healed but the third degree involvement of the hands was markedly infected and painful. The hands were cleansed with

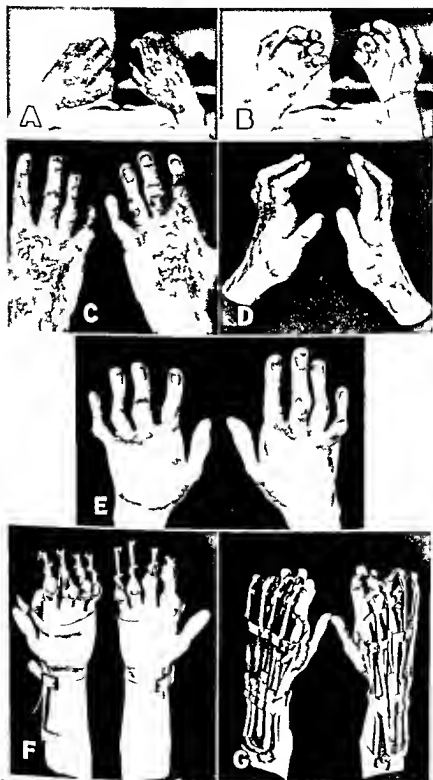


Fig 478 (Case II) —A B 25th day Extensor tendons exposed in several places C D Preliminary grafts have covered the exposed tendons Note marked deformity shown in D E Final healing completed following secondary graft F G Correction splints in place

warm tap water and compression dressings applied. Whirlpool baths were started on the twenty second day (Fig 478 A B). Later thin razor grafts were applied to the denuded areas and exposed tendons by Lieutenant Colonel Schnessler. This early grafting reduced the pain and hastened initial epithelization. By eight weeks occupational and physical therapy were started to increase the metacarpophalangeal flexion and motion available in other joints (Fig 478 C, D). At sixteen weeks the initial scar and unstable epithelium were replaced on the dorsal aspects by thick intermediate dermatome grafts as shown in Fig 478 E. At the end of twenty four weeks healing was complete and orthopedic appliances were devised to assist in rehabilitation (Fig 478 F, G). At present the patient is able to play the piano again. Some minor plastic procedures are further contemplated.

CASE III—Corporal C. L. B. aged twenty six years was aboard the same torpedoed transport and received burns of the face, hand and thighs under the same condition. This soldier's burns were immersed in the sea prior to rescue and he first received treatment in about one hour. In a mild degree of shock he was given plasma and parenteral fluids repeatedly with morphine in half grain doses for pain. The burned areas were débrided and the face and hands dressed with sulfonamide ointment. Tannic acid was sprayed on the thigh burns.

The patient arrived at Walter Reed Hospital sixteen days from the time of injury with healed second degree burns involving 13 per cent of the body surface and deep third degree burns of the hands exposing a number of extensor tendons as seen in Fig 479 A B. After cleansing with warm tap water a compression dressing was applied against a molded plastic volar splint. Whirlpool baths were started on the twenty second day. On the twenty fifth day the raw surfaces were covered with thin Thiersch grafts. Further Thiersch grafting of the areas over the exposed tendons was necessary and this was done on the forty eighth day. Physical therapy was continued from the twenty second day and occupational therapy added at eight weeks to decrease joint ankyloses. At fourteen weeks free tendon transplants from the extensor tendon of the right fifth toe to the right second and third fingers was performed by Lieutenant Colonel Thompson of the orthopedic section. This allowed more extension of the involved fingers. At twenty weeks the heavy scar over the dorsum and proximal portions of the first four fingers of the left hand was excised and covered with a split thickness graft (Fig 479 C D). Further improvement of the left distal and midinterphalangeal joints is precluded by their bony ankylosis.

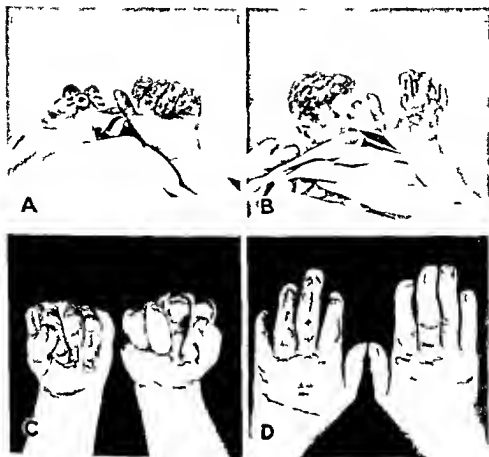


Fig 479 (Case III) —A B 75th day. Note that extensor tendons are exposed in several places C D Deep intermediate graft has been applied to the left hand Extension of right second and third fingers has been made possible by free tendon transplant

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BLAST INJURIES*

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THAT trauma and death can result from the effects of blast incident to a nearby explosion such as a detonation of dynamite or a TNT shell has for long been recognized.

During our Civil War Mitchell Moorhouse and Keen¹ categorically described the effect of blast on the central nervous system. Since that day numerous articles dealing with the various clinical, pathological and histopathological manifestations of this physical entity have appeared in the American, English, German and French literature. Prior to the first World War, however, the majority of these references dealt with injuries to the central nervous system with intrathoracic injuries receiving lesser emphasis.

In 1916-1917 Mott, writing in the *Lancet*, described fatalities due to blast in which the most prominent pathological lesions were in the lungs and vascular system of the brain. Mott at that time also stressed the likelihood of carbon monoxide poisoning playing a significant part in fatalities of this character. The number of soldiers who sustained blast injuries and the number who died of such injuries in World War I is incalculable. There were undoubtedly many thousands. In any event there was much confusion between those physically injured and those suffering from psychogenic trauma. Myers² distinguished between these two syndromes and classified those suffering from organic injury as shell concussion cases and those suffering from psychogenic war neurosis incident to fear and fatigue as shell shock cases.

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The advent of World War II has given tremendous impetus to the interest manifested in the subject of blast crush and compression injuries. This has been largely due to the wholesale bombing of civilian communities from the air and by means of long range artillery and too to the inordinate loss of life from immersion or water blast injuries as the result of mines and torpedoes exploding in the vicinity of men afloat from sinking ships.

MECHANICS OF BLAST INJURIES

There has been considerable diversification of opinion and lack of understanding as regards the physics involved in the production of blast injuries. Some of the best scientific and experimental evidence on this score appears to have been offered by Hooker⁴ and Zukerman. Their experiments with animals showed that the critical distance zone varied with different animals monkeys being particularly resistant and rabbits particularly vulnerable. Moreover it was their conclusion that the positive component of the pressure wave produced by the blast acted externally on the thorax to cause the injury rather than (a) the lowering of alveolar pressure by the negative or suction component of the wave acting through the respiratory passages and thereby causing rupture of the alveolar capillaries or (b) the inrush of air through the air passages causing distention of the lungs.

So far as I know very little appeared in the literature relative to the mechanics and physical effects of water blast injuries prior to 1940.

Considerable experimentation and writing upon the effects of increased pressure incident to deep sea diving and submarine activity has gone on with sustained interest. In 1933 there appeared in the *U. S. Naval Medical Bulletin* an article by Adams and Polak⁵ dealing with the traumatic lung lesions produced in dogs by simulating submarine escape. But in 1941 Bernal⁷ of Cambridge England probably gave the best early descriptions of the physical mechanics of a high explosive wave. This scientist discussing the behavior of high explosive waves for different media has shown that in media of high density and small elasticity such as water the wave travels slowly whereas in media of low density and high elasticity as in air the wave travels at great speed.

The last word has most certainly not been written upon the physical characteristics of either air, ground, or water blast and the mechanics by which lethal trauma is produced on lower animals and man although experimentation and study on this score during the past few years has gone on with increasing vigor in both England and this country.

About a year and a half ago at the U.S. Naval Hospital in Pearl Harbor an interesting series of experiments were conducted by Drs. Friedell and Ecklund.⁸ The sum and substance of their conclusions were as follows:

There are three fundamental determinants in the causation of trauma by blast namely (1) the nature of the explosive force (2) the medium through which the force is transmitted and (3) the distance of the animal from the explosion. The nature of the explosive force embodies the factor of *brisance*, a term the definition of which as Dr. Friedell points out is not easy to propound. Suffice it to say that according to Brunswick⁹ velocity or rapidity of the detonation is the main factor determining the *brisance* of an explosive system. For example mercuric fulminate is a highly brisant explosive. The velocity of detonation is so rapid that it produces its maximum effect instantaneously and this pressure falls rapidly. A slower or less brisant explosive such as TNT will have a less steep gradient in pressure rise and will continue to exert pressure for a longer time and because it holds for a longer time it will be effective for greater distance provided the medium through which it is transmitted is of such character as to prevent its immediate dissipation—therefore the importance of the media.

In air blasts in line with this reasoning the percussive effect or that created by the highly brisant factor is the mischief maker and is responsible for the hemorrhagic lesions produced in the lungs and perhaps in the intestinal tract but no bowel perforation is produced by this force. On the other hand where water is the transmitting medium by reason of its density and relative incompressibility the force of the blast is transmitted slower for a longer distance and with relatively more damaging effect and the brisant nature of the source of the explosion is of prime importance. A rapidly detonating explosive is less effective in water and more effective in air. A slower explosive is more effective in water but in air its pressure

will be dissipated faster than it can be built up. It is believed that this concussive rather than percussive effect transmitted through water from a less brisant explosive pressure is responsible for damage to the intestines notably perforation.

The distance factor has an important bearing upon the situation in that explosives of a lower brisant character are relatively more effective through the water and for a longer distance.

AIR BLAST INJURIES

It has been said that blast injuries should be regarded *a priori* as a total injury of a total war. The validity of this statement I think may well be appreciated when we come to the analysis of a group of cases. For the sake of convenience let us begin at the head.

Head

Undoubtedly more difficulty is encountered and more erroneous conclusions are liable to be drawn when attempt is made to appraise the character and degree of injury to the central nervous system resulting from blast than is the case with any other system or organ. When is the syndrome psychogenic and when is it due to organic brain injury? Myers¹⁰, Roubinovich¹¹ and Stevenson¹ have discussed this problem at length and are all agreed that a distinction upon this score is of essential importance. I believe that more frequently than not there is a mixture of both psychogenic and organic elements but usually the preponderance of symptoms will point to one of these as the paramount disability.

As for the *psychogenic* syndrome the *raison d'être* while maybe less concrete seems more apparent than in the organic. Cases belonging in this category are suffering from a combination of the effects of fatigue, fear and the stress and strain upon the nervous and somatic systems incident to the rigors of war. The term 'shell shock' seems to be a satisfactory one for such patients and to begin with the inherent temperament and attitude of the individual will very likely have constituted a very real predisposing factor. These patients are apprehensive, are introspective, sleep poorly, dream wild and fantastic dreams, have anorexia and lose weight.

On the other hand patients suffering from *organic* brain

injury due to blast or concussion are usually lethargic, cerebrate slowly are indifferent or disinterested are not apprehensive and tend to sleep too much rather than not enough Their appetite is usually normal They usually gain rather than lose weight while in the hospital, but generally speaking seem used up The term 'shell concussion' has been applied to this group

Gratifying and in some instances spectacular results are now being claimed as the result of bilateral trephine and the withdrawal of subdural fluid in certain of these blast injury cases I believe that it is to this latter group that patients amenable to such treatment belong

What are the *mechanics* of this organic brain injury? There are several popular theories However the most plausible are (1) As a result of the tremendous squeeze to the thorax there is a resulting back pressure in the venous system which forces blood into the brain and produces capillary rupture and numerous petechial hemorrhages into the brain substance along with multiple subarachnoid hemorrhages (2) As the result of this venous back pressure the cortical molecular structure or delicate nerve elements are markedly disturbed and may remain permanently so (3) The direct concussion or jar to the head may be sufficient to produce intracranial chaos Rupture to the eardrums is by no means uncommon Hemorrhage into the conjunctiva is also generally common and I have seen one case with retinal detachment

Chest

It seems reasonably certain that insofar as injury from air blast is concerned the death or survival of the patient exposed is more directly dependent upon the amount of pulmonary damage than that done to any other organ or tissue Cardiac damage is also unquestionably quite closely related to pulmonary damage and may actually be chiefly responsible for a number of sudden deaths attributed to pulmonary trauma

As I have already said experimentation by Hooker and Inkerman⁴ seems acceptable as proof that the *etiologic factor* in blast injury to the thoracic organs is the direct squeeze of the positive component of the blast wave Carbon monoxide poisoning may be a contributory or solely responsible factor (Mott²)

Clinically patients suffering from pulmonary blast concussion present a fairly constant picture. The *diagnosis* is not difficult. Shock out of proportion to the apparent trauma is almost always striking as are respiratory difficulty, cyanosis, pallor, cough and restlessness. Pain in the chest, more often lateral than central, is a fairly constant symptom. This pain, while undoubtedly due in a large measure to pleural trauma, may, as has been pointed out by Palma¹³ arise from irritation of the intercostal nerves caused by hemorrhage into their sheaths. Cough, productive of a frothy blood-tinged sputum, not always immediate in development, is paroxysmal and frequently intractable in character. Pallor and cyanosis and in fact all of the aforementioned signs and symptoms will vary with the severity of the injury. The patient is almost always apprehensive and may be extremely restless. Several writers have warned against attributing this nervous syndrome to psychic trauma alone. It may well be due solely and certainly in part to organic brain damage.

The *physical signs* referable especially to the chest consist of a restricted respiratory excursion. Asymmetry is uncommon unless there has been a concomitant crushing injury. I have seen one such case in which there was a paradoxical or pendulous type of respiration. Diminished air intake is of course responsible for the cyanosis. Upon percussion no diminution in resonance may be elicited early, but subsequently areas of dullness may develop and may indicate complications. A pleural effusion may form and cause characteristic flatness. Muffled or distant breath sounds and an assortment of rales are usually heard upon auscultation over the entire chest. A few instances have been described where a concomitant pericardial effusion with distant or absent heart sounds, lowered systolic pressure and an elevated venous pressure, constituting the diagnostic triad, has led to the diagnosis of cardiac tamponade.

X-ray findings are fairly typical and frequently simulate a disseminated pneumonia with ill defined or mottled areas of increased density. The bases rather than the apices are more prone to show abnormal roentgenological findings.

At *autopsy* the more common findings in the chest consist of hemorrhagic areas in the lung. These may be either diffuse throughout the lung parenchyma due to capillary bleeding into the alveolar spaces or there may be massive hemorrhage in the

hilar regions. As would be suspected from roentgenograms the bases more frequently show evidence of trauma than the apices. A variable quantity of blood in the pleural cavity may be explained in terms of multiple lacerations of the alveolar walls at the lung periphery. The bronchi will contain frothy serosanguinous fluid. The pericardial sac may or may not contain an increased amount of fluid. However it is not surprising that when the trauma has been of sufficient magnitude to cause a lethal exodus the pericardial fluid is not only increased in amount but is usually bloody.

And so with these pictures of the living and dead subjects before us we may gain a better understanding of the genesis of their production. Why is the patient inordinately shocked? There has been as a direct result of intrapulmonary capillary damage a marked reduction in the pulmonary vascular bed leading to a corresponding diminution in the blood volume reaching the heart. This is the *sine qua non* requisite for shock. Moreover measures to increase the venous return to the heart must be instituted with caution for it must be apparent that by such measures shock may be increased. Therefore beware of giving a general anesthetic guard against exertion on the part of the patient and give a transfusion only if imperative and then with caution. Why the patient has respiratory difficulty suffers chest pain coughs is cyanotic and restless has already been explained and seems too obvious to warrant further comment. Sudden death from blast is believed to be due more probably to an immediate arrest of the circulation than to ventricular fibrillation.

Treatment—Bed rest is foremost in importance and for its effectiveness early recognition of pulmonary blast injury is mandatory. For shock the usual measures are applicable save that intravenous fluids must as I have just said be given cautiously. Blood plasma is early at least preferable to whole blood. For cough pain and restlessness there is nothing better than morphine. Codeine may be used effectively if cough alone is the chief annoyance. Give fluids particularly hot fluids freely by mouth. Next to absolute bed rest the most helpful measure that can be instituted in the treatment of these cases is oxygen therapy. It may well be life saving and should be administered at the rate of 8 to 12 liters per minute either by tent B L B mask

or nasal tube. As pneumonia is a common complication all serious cases if not all cases should receive sulfa drug therapy. Sulfadiazine in amounts sufficient to maintain a concentration of 15 milligrams per 100 cc of blood is recommended by the best authorities.

WATER OR IMMERSION BLAST INJURIES

Injuries due to water or immersion blast are relatively a newer problem than air blast injuries as was pointed out earlier and like all things new they have fascinated and captured the attention and interest of most military and particularly of Navy doctors.

While the abdomen may come in for its share of insult and in some cases may actually be the location of the more prominent symptoms and signs incident to air blast this is unusual. In water blast however the abdomen is predominantly the seat of the major trauma with the thoracic organs and central nervous system receiving more minor trauma. It is the rule in any event in severe abdominal injuries to find concurrent evidence of thoracic injury. I have seen in a few water blast cases unquestionable evidence of a concurrent brain trauma although here again I think injury to the higher nerve centers is more commonly associated with air blast.

Now of course when a mine or torpedo explodes in the vicinity of men afloat in the water a number may be killed outright and those rescued will show evidence of varying degrees of severity of injury depending upon several factors: (1) their proximity to the blast; (2) the intensity of the blast; (3) whether they were practically completely submerged or whether hanging on to some object they were only partially submerged; (4) whether or not they were swimming on their abdomens or floating on their backs which seems to make some difference; (5) whether or not they were wearing one of the ordinary types of life jacket although this circumstance is a moot question.

Review of Thirty three Cases

I can perhaps do no better than to review briefly a series of thirty three cases of water or immersion blast injuries occurring a year ago last June in the naval battle near Midway Island. In all approximately fifty patients with water blast injuries were

brought to Pearl Harbor at that time. However, some twenty of these patients were admitted to a naval hospital other than the one to which I was attached, and I had the opportunity to follow closely only the thirty-three admitted to the Pearl Harbor Naval Hospital.

That a number of men were killed outright in the water at the time of explosion we know. That a number died in life boats and on rafts we also know. Of the number who survived long enough to be taken aboard destroyers and other rescue ships I believe none died en route to Pearl Harbor. In any event, approximately five days had elapsed between the time of original injury and their arrival at the hospital. Out of the thirty-three admitted to my hospital, over half walked in and required very little definitive treatment. If the ambulatory cases were to be included, the mortality rate in this group of thirty-three would not be terribly high. However, if we include only those casualties who were seriously injured and who were on stretchers at the time of arrival, the mortality rate was very high indeed.

The most characteristic finding for the seriously injured group as a whole was a distended and silent abdomen. Remember, five days had elapsed following injury before these patients reached the hospital. How many of these patients might have been operated upon early if prevailing conditions and circumstances had permitted is difficult to say. I am of the opinion at any rate that all of those who ultimately died would have been operated upon if they had reached the hospital in a matter of hours rather than days, and that the lives of nearly all, if not all, might have been saved.

Those seriously or critically ill upon arrival presented a picture characteristic of intestinal obstruction of the adynamic or paralytic type. Several presented the clinical picture of a superimposed general peritonitis. To have resorted to surgery so belatedly would have merely served to precipitate a lethal state in all of those critically ill.

Röntgenograms revealed free gas beneath the diaphragm in two cases. In one of these instances the patient was moribund and died within a few hours following admission. The other patient did not appear even seriously ill and went on through an uneventful convalescence to complete recovery. A Levin or Miller Abbott tube was introduced in all bedridden patients and

fluids including 5 per cent glucose electrolytes vitamins and blood plasma were given generously by vein All received sulfadiazine by vein in amounts sufficient to maintain a concentration of 15 mg per 100 cc of blood A close record of urinary output was kept Surgery was resorted to in only two cases of this entire group In one an abscess in the right upper abdominal quadrant was drained eleven days after the patient's admission to the hospital or sixteen days following injury Through this drainage opening the greater omentum which was frankly putrescent was delivered in its entirety and removed It had sloughed off completely Through this same opening a segment of gangrenous gut presented a few days postoperatively and upon slight traction it carried away and was found to represent a portion of large bowel about 4 inches in length This spontaneous colostomy closed spontaneously within about a month and normal bowel function was resumed—believe it or not The patient was discharged objectively and subjectively symptom free

The second patient coming to surgery developed a volvulus of the jejunum four weeks after injury which promptly became gangrenous and a 40 cm loop was resected It was found at time of operation that a perforation in the jejunum had sealed itself off against the parietal peritoneum opposite the upper pole of the left kidney and adhesions of the bowel to this point represented the mechanical factor which made such a volvulus possible Only about 1½ inches of sound jejunum remained below Treitz ligament following the resection of the gangrenous segment and continuity of the gut was reestablished by means of a Murphy button

Despite a complicating postoperative pneumonia which gravely threatened the life of this seventeen year old boy he went on to complete recovery and is now again carrying on in the theater of war

All save two of those coming to postmortem examination showed one or more perforations of the bowel with general peritonitis The majority of these perforations were through localized necrotic areas in the jejunum or ileum In one there were two perforations in the large bowel in addition to one or more in the small bowel In one patient no perforation was dem

onstrated. However his cecum and ascending colon were a formless, hemorrhagic necrotic mass. He had developed a peritonitis by reason of extrusion of bacterial organisms through the bowel wall as the result of squeeze which in the opinion of Admiral Surgeon Sir Gordon Gordon Taylor¹⁴ of the Royal Navy is not an unlikely occurrence. One man died of an anuria and uremia. At necropsy his kidney pelvis were found chock full of sulfadiazine crystals.

The *mechanics* of water blast injury like that of air blast injury is a matter about which there has been considerable speculation. The disciples of one school of thought contend that the mischief is done by an inrush of water through the rectum at the time of the blast.

Experimentation with animals and observation at the autopsy table however have shown conclusively it seems to me that this theory is fallacious. In the first place the overwhelming majority of perforations in both experimental animals and human victims has been found in the small bowel frequently in the upper jejunum and not in the region of the rectum. It seems utterly unreasonable that the upper jejunum and not the colon should be the site of rupture due to a force entering the bowel as far away as the rectum. More conclusive than this however is the evidence provided by actual experimentation where it has been shown that within a tank containing several guinea pigs or rabbits some with their rectums plugged or otherwise protected and some without protection but all subjected to the same blast there was no difference between the number, kind or location of perforations in those unprotected and those protected.

Whether or not the perforations in the bowel result immediately at the time of blast squeeze or develop later at the site of areas rendered nonviable and subsequently necrotic as a result of pinch, overdilatation or disturbance of the blood and nerve supply do indeed constitute a score upon which there may be much debate. I personally believe that perforations develop immediately at the time of blast. Corroboratory to this belief I can cite that in his series of water blast experiments at Pearl Harbor Dr. Friedell¹⁵ was able to produce in both guinea pigs and rabbits immediate perforations in both large and small

bowel identical with those seen in humans. Perforations in the small bowel were more numerous and more commonly produced than perforations in the large bowel in Dr Friedell's series.

It is interesting to consider the *subjective symptoms* experienced by individuals at the time of and immediately following water blast injury. All of the patients transferred to the Pearl Harbor Hospital gave a clear description of the sensation experienced at the time of the blast. None of them experienced the sensation of having the breath knocked out of them. They all spoke of a sensation as of having been smacked in the abdomen with a piece of plank. This was followed by a numb feeling. Several were positive that they never lost consciousness. Several thought they were dazed or even unconscious momentarily. Some of them had on no life jackets. The sensation they described was no different from those who did have on life jackets. They all experienced nausea but not severe abdominal cramps early at least. Several vomited blood. None of my patients experienced testicular pain (a symptom generally emphasized by British reporters on this subject) and none a sensation of water being forced into the rectum.

Those who vomited blood must have suffered trauma to their stomachs but in no case coming to autopsy was there gross evidence of stomach injury. In no case in my series was there evidence of rupture of the liver or spleen. Neither was there evidence of physical trauma to the kidneys or bladder. I have seen no diaphragmatic or inguinal hernia attributable to immersion blast compression. I have seen no cases with evidence of injury to the external genitalia.

The only patient in this series who presented *skeletal injury* from water blast was an officer. In addition to evidence of severe abdominal injury this officer was shown by x ray to have sustained a fracture of the body of the second lumbar vertebra along with fractures of the right transverse process of the first, second, third and fourth lumbar vertebrae. All of these fractures must have resulted from pressure since the individual was floating on his back at the time of the explosion, did not lose consciousness and was positive nothing fell and struck him. I have seen no fracture of ribs from blast per se.

While it is generally agreed that the vascular system is more vulnerable than any other to the effects of blast, it is singular

that in no case in this series of water blast injury was there ecchymosis or other well defined skin manifestation of a bruise

Treatment

While there may be something of a mystery surrounding the mechanics of water blast injury there is nothing mysterious it seems to me about the character of the pathological process that is produced by such injury and nothing mysterious about the definitive treatment indicated I have reached the following conclusions in regard to treatment

- 1 The best treatment which could be afforded these patients consists in the introduction of a Miller Abbott tube certainly in all who have been severely enough injured to vomit blood or who otherwise show evidence of severe intestinal injury A deflated bowel will not blow out and even if it would the soilage would be minimized

- 2 A sulfonamide drug should be given either by mouth or parenterally as a prophylactic measure in patients who are regarded as good candidates for perforation Certainly as a therapeutic agent it may well be a lifesaver but miracles cannot be accomplished by its use It is a valuable adjunct to but by no means a substitute for sound surgery

- 3 The maintenance of the patient's water electrolyte protein and vitamin balance is important as is also his daily urinary output

- 4 The patient should be kept under the closest surveillance in order to detect as early as possible the supervention of a surgical entity The necessity for possible surgical intervention should be kept prominently in mind and surgery should be expeditiously instituted when the indication arises If circumstances would permit surgical intervention within twelve hours after the occurrence of a water blast intra abdominal injury the mortality rate should be lower than in perforations of the bowel due to gunshot or stab wounds coming to surgery in a like time following injury

Preventive Measures

As regards what may be done to protect a patient afloat from the effects of compression or water blast, a number of ideas have been evolved in the minds of scientists and doctors working

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PLASTIC SURGERY AS RELATED TO WAR SURGERY*

CAPTAIN H. L. D. KIRKHAM
COMMANDER JAMES T. MILLS

and

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THE development and practically the evolution of a department of plastic surgery in this largest of all naval hospitals has been extremely interesting both from the standpoint of its organization and the types of cases which are presented for treatment.

FUNCTIONS OF A DEPARTMENT OF PLASTIC SURGERY IN MILITARY HOSPITALS

In time of peace in military hospitals there is little or no need for the organization of plastic surgery as a separate specialty because practically the only plastic procedure needed is skin grafting and any larger definitive restorations can be transferred if necessary to such hospitals as have surgeons with training along such lines.

With the conversion of military hospitals from a peace to a war footing it became necessary to consider provisions for the care of patients needing plastic repair or treatment. These considerations not only included the standardized procedures to be used in certain cases but also the training of personnel to render immediate care and in some instances, the later care of casualties. After careful thought we feel it is wiser that the training given be limited to the immediate care of cases needing plastic repair and to the use of thick split skin grafts because these grafts are the most universally applicable in the average plastic case. In addition to this the principle of the Z plastic is taught.

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A case requiring more than these two procedures should be handled at a base where definitive plastic surgery can be performed. It is also felt that to teach what should *not* be done is more valuable even than the short courses in general plastic surgery because (1) it is impossible to train a plastic surgeon in six weeks or six months and the time element is an important factor to be considered (2) such courses could foster a sense of false security and self confidence whereby surgery might be attempted by some who were not adequately competent to use the best judgment in all cases. The sound over all planning of cases needing plastic repair is more important than the actual operative technic.

CAREFUL PRELIMINARY PLANNING OF PROCEDURES

In connection with careful preliminary planning of procedures it is the policy in the organization of the plastic surgery department that each case needing major plastic repair be examined and discussed by the various members. After this a plan is decided upon which in the opinion of the majority is best suited to the needs of the particular case. At the same time an alternate plan is usually worked out in the event that any complications or conditions arise which might render the original plan unfeasible or impractical. By such a system a team is established each member of which knows the complete plan for each case. As a result it is not necessary for one man to follow one case through to completion and it is immaterial which member performs the particular parts of the operation. In this way the department is perpetuated.

The variation to this rule applies to certain one stage procedures for it is obvious that with a staff such as we have one member may be more adept at handling certain types of cases than are the others. It is only fitting and proper that he should have such cases turned over to him. In this way two results are accomplished first and by all means foremost the patient receives the benefit of the very best which we have to give him and second each member of the team is constantly gaining knowledge from his team mates. Both of these factors tend to improve the general status of plastic surgery with the result that everyone receives some benefit and advancement not only during but for the years following the war.

DIFFERENCES IN TYPES OF CASES SEEN IN CIVIL AND MILITARY HOSPITALS

Of necessity there is no essential difference in plastic procedures as performed in civil life from those in military practice. However there is a variation in the types of cases admitted or referred for treatment. Examples of these are seen in the number of severe burn cases resulting from aviation accidents, which in addition to the burns are complicated by multiple injuries often serious fractures and skull injuries. While every effort is made to obtain as satisfactory a cosmetic result as possible it is of even more importance to attain an equally good functional result when functional disability exists. It is fortunate that in most instances both conditions are corrected simultaneously.

Another difference may be noted in the number of patients referred from other services who are suffering from scars following shrapnel or other injuries. Into this class fall amputation stumps referred for release of scar or reamputation. In many of the amputation cases a guillotine type of operation has been performed, and reamputation at a higher level would involve a joint above the original amputation. In order to save the joint it has been found that excision of the scar and the planting of a well padded sleeve or 'pocket' graft over the stump is very successful. Particularly is this true in the case of hand injuries where several fingers have been lost.

In connection with these hand amputations after grafting a prosthetic department has been added to the plastic service in which prosthetic hands and other parts such as noses ears and so forth are made of a vinylite composition which is much lighter and gives a far more pleasing effect than the similar devices made of latex. However they are not as durable. In the case of hands the prosthetic department is at present working on a method of putting ratchet joints in the fingers which will when completed make these hands useful as well as ornamental. The cosmetic appearance of these hands contrasted with that of the usual artificial hand shows the vinylite prostheses to be far superior. The prosthetic hand is colored to match the skin of the other hand and is equipped with nails and real hair. After the original molds for these artificial constructions have been made the patients are taught to make their own appliances thus learning a new form of occupational therapy.

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lation as the case may be. Let it also be said that the simplicity and easy availability of the agent should be taken into consideration. In our opinion all of these specifications are filled by hypertonic saline solution (2/n). The results have been most gratifying. Saline may be applied as a warm wet compress or as a saline bath after the debridement of the gross burned tissue.

There are other advantages to the use of saline: it allows a certain amount of movement while in the bath, thus keeping to a minimum ankyloses of joints and contractures; it also allows the early grifting of granulating areas, thus decreasing the patient's time in the hospital.

Skin grafting should be done as soon as possible, that is, when one is reasonably sure that there is no infection present and when sufficient granulation tissue has been developed. Split grafts of varying thickness depending upon the location in which they are to be used are recommended. Pinch grafts are mentioned only to be condemned, excepting in those cases which require covering as a life saving measure.

Deformities resulting from contractures and various painful and adherent scars are often seen as the end result of severe burns. Contractures occurring about the major joints, hands and neck respond favorably; it is a rule to the proper application of the Z plastic operation. Painful adherent scars in those areas where the Z plastic is not applicable will frequently respond favorably to total excision of the scar and the application of a thick split or free full thickness graft.

Fractures about the Nose and Nasomaxillary Processes

There are many other conditions which we have had to care for some of which we propose to discuss briefly and separately. Not only will we include the injuries resulting from combat but also the cases which have come on this service as direct results of traumatic injury, excluding those that have come from war zones. Fracture of the bones of the face and jaws form a large part of the work in this department. The number of fractures of the maxilla and mandible is too large a topic to include in the scope of this article.

The general care of fractures about the nose and nasomaxillary processes is fairly well understood by everyone. The time element is again an important factor. In all cases, if possible,

SPECIAL TYPES OF INJURY

Burns

With the advent of the present war the subject of burn therapy has assumed a role of increasing importance. Because of the multitude of remedies in vogue at the moment for the treatment of burns it is logical to attempt to clarify the methods used in burn therapy. Principles in the treatment of burns are as important as those in any other branch of surgery and to acquire optimal end results they must be adhered to rigidly.

The treatment of burns may be divided into four general phases: (1) general and supportive treatment of the burned patient; (2) local care of the burn; (3) early skin grafting of granulating areas; (4) plastic correction of deformities resulting from burns.

General supportive treatment is of greatest importance especially early in the treatment of severe burns. In the early stages the treatment consists primarily in the prevention and treatment of shock. It should be remembered that shock resulting from burns is due to loss of blood protein. Plasma should therefore be replaced early and often. The amount of plasma given depends upon the severity of the burn and depth of the shock. In severe cases several liters of plasma may be needed. A formula for calculating the amount of plasma necessary in a given case has been advised by Berkow, i.e. 50 cc of plasma should be given for every per cent of the body surface affected by a blistering burn. The results of the calculation give the total amount of plasma necessary. It should not be administered at one sitting but should be given as follows: one third the first two hours, one third the next four hours, and one third the next six hours.

One should not overlook the other measures of supportive therapy and depend upon plasma alone. Every measure available and indicated should be used—sedation, oxygen, external heat, elevation of the foot of the bed, and so on. Another measure used in extreme cases is the homogenous graft. It is used with no thought that one will get a take, but to save the loss of blood plasma.

The *local care of the burned area* must be constant and particular. In general the objective is to prevent or reduce infection, remove burned debris, and promote epithelization or granu-

small chisel. This however is not done often as the deformity is usually not too disfiguring.

Fractured malar bones present marked problems in some instances. The early fracture that is one which is cared for in the first seven to ten days is not difficult, as a rule. These may be reduced when the swelling subsides by using a hook through the skin and down to the fracture to elevate the malar bone. It is necessary in some displacements to make a canine fossa incision to elevate the fragment through an opening made into the antrum. This is especially true where there is a marked inward backward and downward displacement which will usually involve the orbital floor. A combination of the Gilles method plus the canine fossa approach is sometimes necessary. We do not often resort to packing the antrum but, if necessary, iodoform packing may be left there for two or three days. The use of appliances externally can in most instances be avoided.

Where there is extensive skin destruction and laceration especially in injuries caused by gunshot and shrapnel, it has not been possible for the surgeon in the field to care for the fracture deformities at an early date. These cases present a problem as the deformity is usually quite noticeable and the patient is sensitive to the disfigurement. It is of course some weeks before any extensive surgical interference can be accomplished. Our first goal is the correction of the external scar and deformity. In general however the reconstruction calls mainly for a transplantation of cartilage or fat tissue to overcome the depression that is usually present in this type of injury. We prefer to use a cartilage transplant in most cases. It is gratifying to state that these cases have usually been well cared for in the field at an early stage following the injury and the cosmetic results have been good.

Partial or Complete Obliteration of the Eye Socket

It is true in many of these cases especially in those resulting from gunshot and shrapnel wounds that the eye on the affected side has been destroyed and in some instances, the eye has, of necessity, been removed in the field. With these shrapnel injuries there is naturally some destruction of the eyelids on the affected side with lacerations about the surrounding area. Hav-

ing had emergency care only these cases have presented partial or complete obliteration of the eye socket. These are usually unilateral involvements although they may be bilateral. The eye socket is reconstructed by the use of a split skin graft over modeling compound. The scar in the eye socket is removed and the socket made at least one third larger than normal to allow for the normal contraction which takes place. Following the removal of the modeling compound a stent is placed in the newly formed eye socket and worn for a period of some weeks before an artificial eye is placed in the socket. We try to use as large an artificial eye as possible to begin with since there will be subsequent contraction and gradually we hope a nearly normal eye may be placed in the socket. It has been necessary in some cases to transplant more skin into the eye socket to enlarge it as there was more than the normal amount of contraction following the skin graft. We have reached the conclusion that wide dissection of an eye socket cannot be overstressed and the best end results are obtained with the original skin graft. It is most important to reconstruct an eye socket which will hold an artificial eye similar in size to the unaffected eye.

Eyelid Deformities

The reconstruction of the upper and lower eyelids presents many problems to the operator. If there is no loss other than the external skin the case can be very easily handled by the use of a free graft taken from the opposite upper eyelid or from behind one or both ears. These grafts are carefully sutured in place and held firmly by modeling compound and pressure dressing. It is sometimes necessary to transfer mucous membrane from the upper to the lower lid and this is accomplished by the Dupey Dutemps operation. Should there be a complete loss of the upper or lower eyelid or both the use of pedicle flaps from about the involved areas which were previously lined with skin before transfer is the best method. It is not possible in this paper to discuss in detail the many methods involved in various types of eyelid deformities. It is important however that the surgeon must always endeavor to add as little as possible to the existing deformity about the operative area.

Extensive Tissue Loss about Face

For the large repairs necessitated by extensive loss of tissue about the face the use of the pedicle flap is usually necessary. More and more we are making it the general rule that pedicle flaps be constructed at least one third larger than the area to be repaired. This has given much better results as there is definite contraction in these pedicles, and when they are transplanted with sufficient pedicle flap the end result is far more satisfactory.

Deformities of the Ears

The plastic repair of deformities of the ears which are a direct result of traumatic injury, burns, or loss produced by shrapnel wounds is still a very difficult surgical problem. Partial reconstructions are fairly simply handled. The method has been previously described in this paper.

TRACTION REDUCTION OF FRACTURES ABOUT THE WRIST*

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Med cal Corps United States Navy (Ret)

THE numerous methods of reduction of fractures and dislocations about the wrist such as the use of the Thomas wrench the triangular block and especially the ju jitsu method of yanking pushing and pulling, all depend on the use of force for reduction. Any of these methods cause additional trauma at the site of fracture and even at times cause permanent damage to tendons nerves and vessels. These mechanical methods of applying force also often cause the breaking off of fragments which may be interposed in the fracture line or displaced and cause a deformity.

All of these dangers can be so easily avoided by the judicious use of traction. The art of traction as expounded by Bohler seems to have been completely missed or perhaps forgotten. The method I have personally used for ten years and which has been used at this hospital since November 1940, employs the fixed traction method as described by Bohler plus the old Chinese finger traps as developed by Caldwell. Our addition has been to use a spring scale in the traction and a definite amount of measured traction for a fixed period of time.

To use fixed traction properly one must bear in mind the principles of traction. The extremity must first be so postured that all muscles involved extensors and flexors are in physiological equilibrium. If continuous fixed traction is then applied for a period of time sufficient to tire the muscles completely

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a hollow muscle tube will result with equalized tension on all sides of the bone so that fractured and displaced fragments under the gentle equalized pressure seek their proper positions

TECHNIC

1 The needle is inserted in the blood clot at the side of fracture and 30 cc of a 2 per cent novocain solution is injected

2 At least five minutes by the clock is allowed for the local anesthetic to take effect



Fig 480—Application of fixed traction in fractures about the wrist. To Bohler's method has been added the use of finger traps and a spring scale. The upper arm is at an angle of 90 degrees with the body and the elbow is bent 90 degrees. The arm is in pronation. Pull is in ulnar deviation at 15 pounds for fifteen minutes. The arm is not manipulated or checked for fifteen minutes by the clock.

3 The arm is then abducted 90 degrees from the body (Fig 480) the elbow at 90 degrees to the upper arm. The arm is fastened to the wall by a canvas sling. The sling is spread by an 8 inch board so as not to shut off the circulation. The forearm is placed in pronation and the finger traps are applied. Adhesive strips are placed on each side of each finger to protect the skin. The finger trap bar is now fastened by a spring scale to an assistant and he is instructed to pull 15 pounds.

4 The pull on the bar must be so balanced that the hand is in ulnar deviation

5 Now comes the most difficult but at the same time the most important feature of the technic As Bohler insisted the surgeon must remain at ease in the room or preferably leave the room for fifteen minutes by the clock Under no circumstances must the arm be manipulated or touched during this period

RESULTS

In our hands this method makes the reduction of fractures about the wrist delightfully easy In cases of dislocated carpals especially semilunars and scaphoids reduction has been complete (Figs 481 482) Simple Colles fractures respond if the waiting period is adequate Occasionally slight impaction may be applied but only after fifteen minutes of waiting (Figs 482 483 484) Severely comminuted and displaced fractures apparently reduce themselves most completely even to the smallest fragments (Figs 483, 485 486 487) Both bones of the forearm will be so nearly in position that very little manual adjustment is needed and this adjustment must not be made until after fifteen minutes of fixed traction A posterior plaster splint is applied under traction and allowed to harden Needless to say that owing to the lack of manipulation edema and pain are minimized

It must be noted that if the fracture line extends through the articular surface of the head of the radius reduction will take place but displacement will recur unless some form of fixed traction is used In these cases this method is used for reduction but a 2 mm wire is put through the metacarpals and a 2 mm wire through the upper end of the ulna and these are incorporated in the plaster cast This maintained fixed traction retains the fragments in place and gives excellent results

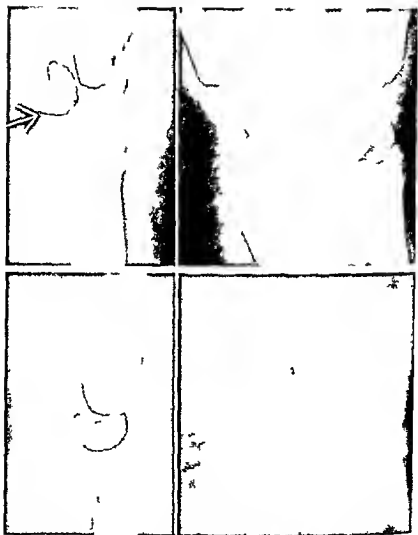


Fig. 481—*Upper*: Distraction of the semilunar and one half of the scaphoid.
Lower: Reduction complete in fifteen minutes. Arm not even touched.

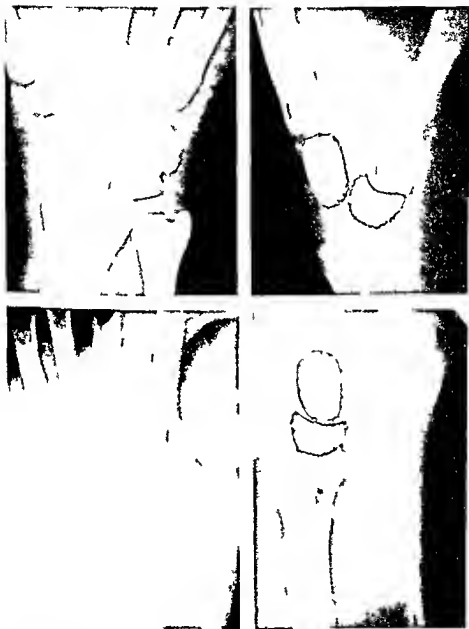


Fig 482—*Upper* Another instance of dislocation of the semilunar and one half of scaphoid *Lower* Reduction complete in fifteen minutes Wrist or arm not touched



Fig. 483—Typical Collapsed rock deformity

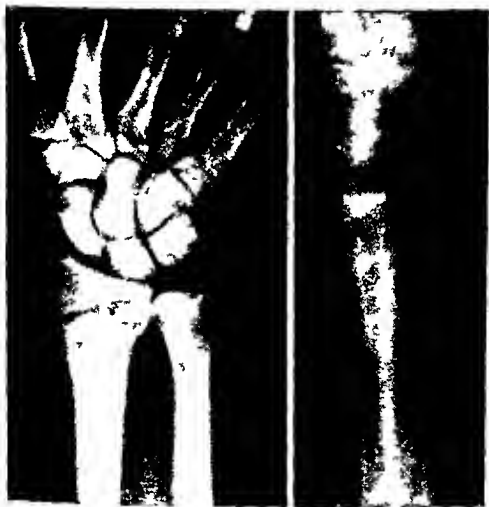


Fig 484—Same case as Figure 483 after application of traction of 15 pounds for fifteen minutes. The fracture was not touched by hand. Note that even the fragment is in place.

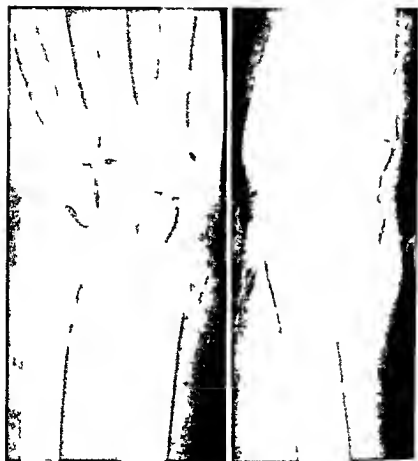


Fig 485—Thin slice of ulna and radius displaced posteriorly as the result of a compressed air explosion (See also Figs 486 and 487)



Fig 486—Same case as Figure 485 The x ray was taken after the application of 15 pounds of traction for fifteen minutes Reduction was automatic, the arm not being manipulated or even touched by hand Note the wide spacing of the joint and carpals (See also Fig 487)

By this method the patient is immediately comfortable and shock is lessened. Many of the simpler types of fractures will reduce anatomically and traction is then continued throughout the treatment. If traction fails to reduce the fracture after seven days a mechanical problem exists and the fracture is plated unless a complication such as a chest or head injury is present.

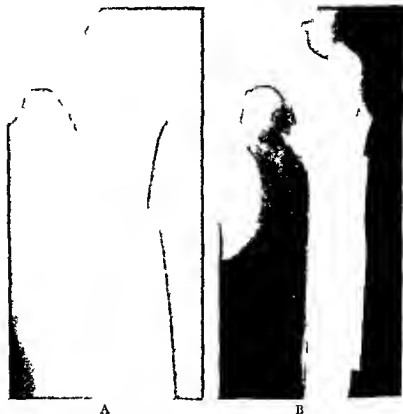


Fig. 488—A A comminuted fracture of the upper third of the femur in three fragments. B The plate applied. Two separate screws inserted. One separate screw placed too close to plate which is undesirable as the strength of plate is weakened.

Plating has been done in the majority of our cases between the seventh and fourteenth day. We have found no delay in callus formation by waiting this length of time.

The preliminary fixation of large comminuted fragments with a separate screw placed away from the site of plating aids materially in the ease and accuracy of anatomical reduction. It is also

essential to use two plates nested together to provide added strength. The plates are so constructed that one fits easily over another, and the length of the plate naturally depends on the type of fracture. Plating a femur is a mechanical problem requiring accurate placement of the plate and angulation of the screws to



Fig 489—A comminuted fracture of lower third of femur showing complete union in four months. This man was able to bear full weight in eight weeks.

obtain maximum strength especially across the fracture line and securing the screws as tightly as possible. No external fixation is used and the patient is encouraged to exercise the muscles of the leg actively; however, bed rest should be maintained for four weeks followed by crutches until x-ray evidence of callus formation is found.



Fig. 490—Showing what we consider a perfect type of plating in a transverse fracture of the femur.

CONCLUSION

1 Open reduction and plating of fractures of the femur with the Townsend and Gilfillan plate and screws markedly lessens complications and reduces the length of disability 50 per cent.

2 This plate and screws if properly applied give such rigid fixation that external fixation is not necessary thus avoiding muscle atrophy and residual limitation of knee motion.

3 All of our cases showed early union.

THE MANAGEMENT OF ACUTE HEAD INJURIES*

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FROM the fact that so many questions are asked by the medical profession regarding the management of head injuries, one can only infer that in spite of all that has been written no single regimen of treatment has been generally accepted. It appears that too much emphasis has been placed on the use of certain procedures rather than on the explanation of the fundamental principles involved as witnessed by the fact that the two questions most frequently asked are "What is the best drug to use for dehydration?" and "When should a spinal puncture be done?" My only excuse for adding to an already too voluminous literature on the subject is the hope that I may be able to clarify certain principles in such a manner as to be of benefit to medical officers in the armed forces who are out of contact with anyone who has a particular knowledge of neurosurgery.

Let me state in the beginning that in my opinion the treatment of head injuries is not primarily a problem for the neurosurgeon but rather for the general surgeon and the general practitioner. This is necessarily so for head injuries do not in any large percentage of cases occur in a location where a neurosurgeon happens to be and in most instances the patient must be treated by local physicians with available local facilities. For this reason it is all important that fundamental principles be generally understood for in many instances ultimate outcome depends on procedures adopted within the first few hours following the injury.

Head injuries like injuries to any other part of the body

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may be accompanied by shock. If therefore one is faced with a patient who has evidence of a head injury plus the signs of shock the head injury should be disregarded except for the simple control of superficial hemorrhage until the shock has been controlled or greatly improved. Likewise the patient with a head injury may have other injuries so that a quick but thorough examination of extremities, spine, chest and abdomen should never be neglected.

The next important question that comes up is: Will the patient require surgery or will the management be along non-surgical lines? In some cases the ultimate decision may require hours of observation while in others it may be obvious at a glance but in any event one should know which cases are best treated by surgical intervention and which should be left alone. Therefore for practical purposes it seems wise to classify these cases into operative and nonoperative groups.

OPERATIVE GROUP

- 1 Compound fractures
 - (a) Linear
 - (b) Depressed
- 2 Depressed fractures (not compounded)
- 3 Arterial hemorrhage middle meningeal trunk or one of its large branches
- 4 Miscellaneous group

1 Compound Fractures: Linear or Depressed

A compound fracture of the skull is a simple combination of skull fracture plus laceration of the overlying scalp. If the fracture is merely a linear crack therapy should be directed along the lines of preventing infection and once this has been accomplished the treatment does not differ from that of the simple linear fracture. The avoidance of infection is of great importance for its presence may lead to meningitis or brain abscess.

The treatment of compound depressed fractures is more complicated for not only is infection more likely to occur but damage to the underlying brain and meninges must be reduced to a minimum. In both types *early diagnosis* will shorten the interval between occurrence and treatment and since the danger of infection increases with each hour's delay *the institution of*

treatment at the earliest possible moment is of paramount importance

Under wartime conditions it is not always possible to have access to a complete diagnostic armamentarium and a return to simple means is inevitable. This merely means that instead of relying too much on x ray films for diagnosis the senses of vision and touch are brought out of retirement. After shaving and cleansing a large area around the open scalp wound sterile fingers are used to separate the edges and to probe its depths for evidence of fracture. If no fracture is found or if there is only a linear crack the wound is thoroughly irrigated with sterile saline the skin edges debrided and closure effected by using interrupted sutures of cotton or silk in the galea and skin. It is important to remember that the use of nonabsorbable suture material entails careful technic so that the surrounding skin should be kept covered to prevent the ends of the suture from dragging across it. One should also acquire the habit of cutting the suture on the knot rather than leaving excess suture as is so commonly done with catgut. If considerable time has elapsed since injury or if the wound is grossly contaminated sulfanilamide may be placed in the wound before closure but *sulfathiazole should never be used* for it has been conclusively demonstrated that this substance may cause violent convulsions when in contact with the brain.

If the inspecting finger encounters comminution and depression of fragments a *radical debridement* is necessary and the best available surgical facilities should be provided. The two things which are essential to the success of such a procedure are suction and a method of hemostasis. Practice and experience have shown that if these two essential factors are not available the patient will stand a better chance for recovery if his removal to some hospital where they are available does not entail too long a delay—not more than twelve to sixteen hours.

The actual technic of the procedure is relatively simple under proper conditions and with the mechanical essentials. My practice is to shave widely around the wound and then with soap, water and alcohol prepare a circular area around the periphery of the field. This area is then infiltrated with 0.5 per cent procaine solution containing 3 drops of adrenalin to the ounce. This circular infiltration will anesthetize the operative area so that

thorough irrigation and cleansing may be done without pain to the patient. The field is then carefully draped, the operator's gloves changed and the actual debridement begun. All torn skin edges should be trimmed away and hemostasis of the scalp edges effected by hemostats applied to the galea or by some type of skin clip. Torn muscle or periosteum is then trimmed away and the indriven and loose fragments of bone removed. If these fragments seem relatively clean they should be placed either in gauze moistened with saline or in a beaker of saline to be replaced at the end of the brain and dural debridement. In many instances there are *indriven bone fragments* which are wedged in so tightly that they cannot be lifted out. Under such circumstances it is wise to make an opening in the bone with a perforator and burr immediately adjacent to the fracture line. Then with a rongeur the bone along the edge may be removed, thus freeing the fragments and permitting their removal. The torn edges of the dura if macerated or obviously contaminated are removed and the dura opened more widely to permit inspection of the underlying cortex. This opening should be made in such a manner as to facilitate closure of the dura when the brain debridement is completed.

As an initial step in handling the brain debridement bleeding from readily accessible torn vessels should be controlled either by the use of the electrocoagulation unit or silver clips. Then with suction macerated and hemorrhagic brain tissue is removed and as this removal is effected any bleeding vessels encountered are drawn up into the suction tip and occluded either by coagulation or silver clip. When the obviously destroyed cerebral tissue has been removed it is wise to pack loosely the field with cotton or cottonoid moistened in normal saline at about 105° F for a few moments. This will aid in hemostasis from very small vessels and identify bleeding points which require attention. No normal brain tissue should be removed and for this reason the suction tip should have an opening which has to be covered by the thumb so that instantaneous release of suction is possible at all times.

When the field is dry the dura is sutured with interrupted sutures of fine cotton or silk previously waxed with bone wax. The *closure of the dura* is one of the most important steps in the procedure and should be done if possible even though some

of the membrane has been torn away. In some instances the normal dura may be separated into two layers and the outer layer turned over to cover the defect. In other instances a small free graft of periosteum or fascia may be used but if either of these latter procedures is carried out the strictest asepsis must be observed.

After the dura has been closed, bone fragments may be replaced if the operator feels that the wound is free of infection but if doubt exists they should be left out. The rest of the closure is done in layers including the periosteum if possible with interrupted sutures. No drain is used. Skin sutures are for loose approximation only and may be removed at the end of twenty-four hours.

If the operation has been delayed for several hours and the possibility of infection is definite in spite of thorough debridement *sulfamylamide* may be used in the wound. The amount placed in the cavity in the cortex should not be excessive merely enough to give a covering about 1 mm. in thickness, and *sulfamylamide*, not *sulfathiazole*, should be used.

The *postoperative care* consists of careful nursing, adequate fluid intake and bed rest with the head elevated to minimize bleeding. The patient is allowed up in a wheel chair in eight to ten days and should be able to begin some sort of light duty in three to four weeks.

In a war period something must be said regarding *penetrating wounds* of the head. These wounds are simply compound fractures and should be so treated but the decision for or against the radical removal of the foreign body is one which entails judgment. By and large in these cases radiographic studies in at least lateral and anteroposterior views should be made. Then one should determine whether the removal of the piece of material will produce more brain damage than already exists and on this factor alone a decision may be reached. For example if a missile has entered the right frontal region, traversed the right frontal lobe and fallen and lodged in the left frontal lobe its removal might entail going through undamaged left frontal lobe tissue. In this instance it should be left alone. On the other hand if the foreign body may be reached by going through the original point of entry its removal is in order.

2 Simple Depressed Fractures

The treatment of simple depressed fractures is usually a much less complicated procedure and has as its aim the elevation of the depressed bone and minimizing of brain damage. In my opinion it is wiser in most instances to make a perforator opening immediately adjacent to the depressed area and with a rongeur remove enough bone so that the depressed fragments may be lifted out rather than attempting to force them into position with some sort of elevator. If they are lifted up damage to the underlying dura and brain may be inspected and dealt with and the fragments then replaced.

3 Middle Meningeal Hemorrhage

From earlier texts on neurosurgical subjects an erroneous conception has arisen that injuries producing middle meningeal hemorrhage are common. Actually this type of injury is very rare but when it does occur it is unlikely that it will follow the much emphasized pattern of unconsciousness, consciousness and unconsciousness again with a slow pulse and rising blood pressure. One is very fortunate if the diagnosis is so easily arrived at for in my experience the symptomatology has been very varied. I now have a rule that the diagnosis is actually made only when a small perforator opening discloses an extradural clot but the chain of events leading to this procedure is one of suspicion.

Given a patient who has had a blow on the head who is or is becoming very restless or unconscious the first suspicion is aroused. If he develops a dilated pupil, signs of unilateral weakness or merely fails to improve as he should in a given period of time then under local anesthesia a small opening in the bone is made through a straight incision in the temporal region. If this discloses a clot then the straight incision is enlarged upward and a routine subtemporal decompression is made. The clot is then sucked out and the bleeding vessel controlled by electrocoagulation or by plugging the foramen spinosum. When this major hemorrhage has been controlled one then finds that the dissection of the dura from the bone has started numerous areas of slow oozing. The larger of these may be controlled either by coagulation or small muscle stamps but many of them will stop only when the dura has been brought up against the bone and

held there by means of sutures tied either to the periosteum or temporal muscle. When the field is dry, closure is done in layers being very careful to close the temporal fascia.

If the diagnosis is made reasonably early, these cases usually have a prompt and satisfactory recovery with no especial post operative care.

4 Miscellaneous Group

In addition to the above given groups one occasionally sees a patient in whom there is definite evidence of focal brain damage without evidence of a fracture. If, after a period of observation satisfactory progress toward recovery is not made an exploration is in order. Not infrequently an intradural clot or a large collection of subdural fluid will be encountered the evacuation of which will cause immediate improvement. In any of these cases unless the emergency is great the patient should be transported by air if needs be, to some organization where proper facilities are available.

NONOPERATIVE GROUP

From what has been said one might think that I believe that active surgery is usually necessary in the treatment of head injuries. This is not true for the great majority of head injuries do not require operation but the all important thing is to be able to pick out those which do. The average patient who comes in does not show signs of focal brain damage. There may be unconsciousness for a variable period of time headache restlessness and photophobia. These symptoms are due to the initial damage plus the secondary increased intracranial pressure. It is in this group that so much argument has arisen as to the advisability of spinal puncture and dehydration. This is a controversy which I hope to avoid for I feel that there is a middle ground which is in the light of our present knowledge the proper course.

In my experience *spinal puncture* is never necessary as a routine procedure. It may, however be valuable in two instances one diagnostic the other therapeutic.

From the diagnostic angle there are certain instances when the presence or absence of blood in the spinal fluid may mean much. The prime purpose of the medical officer in the armed

forces is to return a man to duty at the earliest possible moment. Not infrequently individuals are brought in in varying degrees of unconsciousness in whom alcohol is evident and history absent or scanty. There may be a history of a fall with perhaps contusion of the scalp but alcohol could easily account for both. However it is always unwise to make a hasty diagnosis and great care should be taken to rule out a head injury. A carefully done spinal puncture with measurement of pressure and examination of the fluid for blood may decide the issue so that the individual may be either promptly returned to duty or given proper care.

As a therapeutic measure spinal puncture may be used to great advantage in the individual who several days after an injury develops a stiff neck, slight fever and increased headache. The removal of 25 to 40 cc. of fluid containing hemolyzed red cells will give prompt relief and may be repeated if the occasion demands. In any of these instances in which a spinal puncture is done the pressure should be measured but jugular pressure should not be applied for this may by increasing intracranial pressure start fresh bleeding.

As to the question of *dehydration* I can only say that in my opinion the controversies have outweighed the clinical importance. I seriously doubt that any permanent good will result from concentrated glucose, sucrose, etc., though it is true that in certain instances symptomatic relief is obtained. To my mind the important thing is to prevent the ingestion of large quantities of fluid; consequently the patient with evidence of increased intracranial pressure but no signs of localized brain damage is given only 1000 to 1500 cc. of fluid daily depending on age, sex, state of weather and so on.

When these conditions have been met one needs only to emphasize a period of *bed rest*, good food and good nursing to restore the patient to health. I have also become convinced since being in regimented military service that we may have at times insisted on too long a period of bed rest. In many instances I have seen very definite neurotic trends develop in an individual merely because the seriousness of his injury was overemphasized by a long period in bed. On the other hand many other individuals have taken advantage of the medical officer's absence from the ward to get up and since none of

these have shown any ill effects, I frequently allow these patients up in a wheel chair as early as seven days after the injury. They are not discharged from the hospital in less than three weeks but they are frequently given some light duty to perform as early as two weeks after injury.

Little has been said about x ray. My feeling is that the *radio graphic examination* is important and should always be made when three conditions can be met. First the patient must be in such a condition that the moving necessary to the procedure will not harm him. This certainly precludes even the thought of x rays while the patient is in shock. Second the equipment and technical help must be such that decent pictures will result for skull films are at best difficult of correct interpretation. Third there must be an individual present to read the films properly for many a legal controversy has arisen and many days have been lost from duty because a suture line, a vascular groove or some other normal anatomic variant has been incorrectly interpreted and so written in the record.

The foregoing principles have worked out successfully both in civil and military practice. They are not original and no attempt has been made to search through the literature and find the source for each idea. They apply only to the *acute* head injury and no attempt has been made to deal with late complications or unusual types of injuries.

SUMMARY

A practical method for handling acute head injuries is presented.

Operative procedures are outlined and methods are suggested for the handling of patients who do not require operation.

THE MANAGEMENT OF COMPOUND COMMINUTED FRACTURES OF THE LONG BONES*

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and

LIEUTENANT PINCKNEY HARRAL

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This report concerns the late management of compound fractures of the long bones sustained in action by Naval and Marine personnel in the southwest Pacific. The great majority of these wounds were caused by bullets and high explosive fragments.

The scope of this paper is necessarily limited, as it originated from observations on patients in the US Naval Hospital Oakland, California, where the injured sailor or marine has been received an indefinite time after his injury. In some instances the health record of the injured man has been lost at sea; in others the first medical officer in a position to record an accurate history of the injury has been too pressed for time to write more than the briefest account of the injury and treatment. Also, in many cases, a detailed account of the mechanism of injury, the type of first aid, the intervals of time and various other factors considered so essential in the management of these injuries cannot possibly be recorded because the patient was rendered unconscious immediately.

The full significance of the term 'global war' is quickly understood by those who treat the injured brought in from distant fronts. The great problem created by the length of time required for transportation to the mainland is matched only by the serious difficulty encountered in supplying adequate first aid dressing stations and field hospitals in the battle areas. It

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almost seems appropriate to prefix "time space" to the diagnosis of compound fracture to indicate the added hazards of treating these wounds as compared with similar injuries in civilian life. The excellent general condition of these patients on arrival, however, is a real tribute to the organization, quality of equipment and skill of the personnel encountered by these boys on the long road home from the battle front.

ILLUSTRATIVE CASES

Because conditions are so different from those usually encountered in dealing with compound fractures of the long bones, it is of interest to trace the evacuation of the injured and to observe the type of treatment accorded them. Four representative cases illustrative of the present methods of management are reported here.

Case I. Compound Comminuted Fracture of the Middle Third of Right Tibia. Orr Dressings. Chemotherapy.

E. R. W., a Marine private twenty years of age, was returning from a patrol on Guadalcanal when an enemy sniper shot him in the right leg, causing a fracture of the tibia. He crawled 300 yards to the front line where morphine was administered, sulfanilamide was dusted into the wound, it was covered with a gauze dressing and a wooden splint was applied. He was taken by Jeep to the first aid dressing station where his wound was inspected, redressed and he received one unit of plasma. He was then removed by ambulance to the field hospital. Two hours after his injury, under pentothal sodium anesthesia, the wound was excised and a diagnosis of compound comminuted fracture of the middle third of the right tibia was established. More sulfanilamide was introduced into the wound and an Orr dressing was applied. The following day the patient was taken by air transport to a hospital ship which carried him to a base hospital. On the hospital ship a second Orr dressing was performed under spinal anesthesia. Nine days later at the base hospital the Orr dressing was repeated without anesthesia. The patient remained at this hospital for two weeks and then was transferred to the United States by transport vessel.

The patient arrived at the US Naval Hospital, Oakland, five weeks after injury. On admission his general condition was good and his fracture was well immobilized in a long leg cast.



FIG. 491 (Case 1) —A Lateral roentgenogram on entry (Jan. 6 1943) B Anteroposterior roentgenogram on entry C Anteroposterior and lateral roentgenograms June 25 1943

X ray examination showed a severely comminuted fracture of the middle third of the right tibia with considerable loss of the crest of the bone. Position and alignment were satisfactory (Fig 491 A, B). The wound was inspected under pentothal sodium anesthesia. There was profuse purulent discharge but the granulations appeared healthy. The wound was excised including many small sequestra. A mixture of sulfanilamide and sulfathiazole was sprayed into the wound which was then picked with vaseline gauze and an unpadded long leg cast incorporating a walking iron was applied. His progress to date has been satisfactory. The fractures have healed rapidly and the osteomyelitis is gradually subsiding (Fig 491 C). Orr dressings have been repeated at intervals of from four to six weeks. The patient is now being fitted with a long caliper brace which we feel is necessary because of the great loss of bone. It is our belief that early weight bearing in plaster accelerates bony union and the healing of the wound.

Case II Compound Comminuted Fracture at Junction of Upper and Middle Thirds of Right Femur Late Amputation Phagedenic Ulceration in Stump Arrested by Electrothermic Excision and Continuous Salt Bath Penicillin Therapy

W A M a Chief Signalman twenty six years of age sustained a compound comminuted fracture at the junction of the upper and middle thirds of his right femur when struck by a high explosive fragment while at his battle station on the bridge of a light cruiser. He lay unconscious for two hours before being brought to the sick bay. There he was given morphine his wounds were dressed and his leg was immobilized in a Thomas splint. Four hours after injury he was taken by Higgins boat to a field hospital on Guadalcanal where his wounds were redressed. The patient was then flown to an island base hospital arriving two and a half days after injury. There for the first time he received definitive treatment consisting of excision of the wound application of sulfanilamide powder and a vaseline gauze pack. Skeletal traction in a Thomas splint was obtained by means of a Steinman pin through the os calcis. (Apparently the reason for the long delay before definitive treatment in this case was the fact that this man was injured in heavy action when there were a great number of other casualties.) Osteomyelitis developed at the site of the fracture and progressed sufficiently

it require a subtrochanteric guillotine amputation even week after injury. Many transfusions of blood were given. Two weeks after amputation the patient was transferred to another big hospital by hospital ship and dressings and transfusion of blood were continued. After a short stay he was sent to the United States by transport. During this interval a progressive infection developed in the stump especially at the margins of the wound.

The patient arrived in Oakland approximately three months after injury. His condition was critical as evidenced by emaciation, meningitis and a septic temperature curve. He was suffering severe pain. His amputation wound had been invaded by a microbe hemolytic streptococcus which had resulted in a phagedenic ulceration extending up on to the anterior abdominal wall and posteriorly over the buttock. From under the edges of the skin approximately 500 cc of thick yellow pus drained daily. The adductor tendons had been destroyed permitting an abduction contracture of 70 degrees (Fig. 492 A).

The patient was placed immediately upon a regimen of daily transfusions of blood, high caloric diet, vitamins and daily dressings with zinc peroxide and salt solution. At first these dressings required the use of methesin. The margins of the skin were debrided on several occasions, but improvement was only temporary. At the end of a month when no progress was evident continuous irrigation was instituted using alternately Dakin's solution, zinc peroxide and saline solution. Progressive ulceration continued, however, and finally when the patient's condition had become desperate the margins of the skin were excised with the high frequency knife and he was placed in a bath of salt solution and left there for ten days. These procedures were undoubtedly life saving. His systemic and local responses were highly gratifying. Improvement was so rapid that within the next two weeks split thickness skin grafts were placed on the large granulating area involving the entire stump, buttocks and lower abdomen (Fig. 492 B).

At about this time it became evident that the right ilium and pubic bones had become involved in the infection. An abscess developed in the space of Icterus and again a microbe hemolytic streptococcus was demonstrated as the pathogenic organism. The abscess spread to the left thigh and up along the abdominal wall causing a severe sloughing of the interior sheaths

tion and alignment except for moderate lateral bowing (Fig 493 A, B). On removal of the cast a healthy granulating wound was found on the lateral aspect of the middle third of the thigh with a sinus connecting the fracture site. There was minimal drainage. The wound was excised including several minute sequestra, packed with sulfanilamide and vaseline gauze and im-



Fig 493 (Case III) — A Anteroposterior roentgenogram on entry B Lateral roentgenogram on entry C Anteroposterior roentgenogram two months later D Lateral roentgenogram two months later

mobilized in an unpadded spica cast. The head of the patient's bed was elevated to promote dependent drainage.

Two months after entry (four and a half months after injury) the patient had secured firm bony union and had become ambulatory on crutches without a cast (Fig 493 C, D). Within another month the wound had completely healed and the crutches were discarded for a cane. Since the removal of the

cast daily physical therapy has been instituted consisting of whirlpool baths ultraviolet light treatments and progressive exercises

This case illustrates several points Foremost it suggests the probable beneficial effect of the prolonged saline bath to which this compound wound was subjected for it will be recalled that this man spent five hours in the water before being rescued There is an impression among naval medical officers who have had experience in the treatment of these compound fractures that the clinical course of the patient who has been forced to stay in the sea any length of time is likely to be much smoother infection much less and ultimate rehabilitation more quickly accomplished than in the case of others

The postural treatment of these wounds of the thigh to secure dependent drainage has been of great value in arresting progress of the infection along the fascial planes toward the hip

We believe that the whirlpool bath the use of soapy water together with progressive exposure of the wound to ultraviolet light has speeded healing of the wound and wherever possible casts are bivalved and the patient is started on such a regimen at the earliest moment

Case IV Compound Comminuted Supracondylar Fracture of Right Femur Gross Infection Controlled by Postural (Gravity) Drainage and Supportive Measures

E D B Fireman First Class twenty years of age sustained a compound comminuted supracondylar fracture of the right femur as a result of a high explosive fragment This occurred as he was standing on the second deck of a light cruiser awaiting orders to abandon ship He was evacuated by Higgins boat to the beach at Guadalcanal arriving there fourteen hours after his injury On the beach a corpsman administered morphine applied a dry sulfanilamide dressing and immobilized the leg in a Thomas splint The patient was then transported to a field hospital where under pentothal sodium anesthesia his wound was debrided packed with sulfanilamide and vaseline gauze and the splint was reapplied without traction Shock was combated with three units of plasma and more morphine Approximately two days after injury he was flown to a distant island base hospital where for the first time an attempt was made to reduce the fracture Under spinal anesthesia the wound was excised and packed with sulfanilamide and vaseline gauze A

Steinman pin was inserted through the upper end of the tibia and the leg again placed in a Thomas splint with 45 pounds of traction applied. At the end of eight days no appreciable improvement could be seen consequently a hip spica cast incorporating the pin was substituted and the patient was sent by hospital ship to another base hospital. Essentially the same program of treatment was tried again without success and the patient then was returned by transport to the mainland.

This patient arrived in Oakland one and a half months after injury. His general condition was serious; he exhibited a high septic fever and was anemic and considerably emaciated. Because of persistent almost uncontrollable pain he begged for amputation. The extremities were immobilized in a bilateral hip spica cast. There was considerable drainage through the cast about the lower part of the thigh and around the protruding Steinman pin. A ray examination showed a markedly comminuted supracondylar fracture of the femur with a posterior angulation of 90 degrees (Fig. 494 A, B). Fortunately there was inconsequential neurocirculatory disturbance below the knee. After several days of supportive treatment his cast and pin were removed under pentothal sodium anesthesia. The compound wound on the lateral supracondylar area was greatly infected as were the pin holes. The articular ends of the femoral condyles presented in the wound and many loose fragments of bone were visible. The extent of the wound was visualized by introducing iodine and multiple tracts were seen to extend up the thigh from the wound (Fig. 494 C). The main wound and the pin wounds were excised. The fracture was manipulated manually inside the wound, the angulation being reduced from 90 to 45 degrees as was later borne out by x-ray studies. All wounds were packed with sulfanilamide and vaseline gauze. At this point the patient went into profound shock. Because of his condition and because of marked decubitis about the pelvis a long leg unpadded cast was applied instead of the customary spica cast of the hip. Before leaving the table the patient had received one unit of plasma and 500 cc. of citrated blood which caused him to rally sufficiently to be returned to the ward.

With continued supportive treatment consisting of elevation of the head of the bed for better drainage at least ten trans-

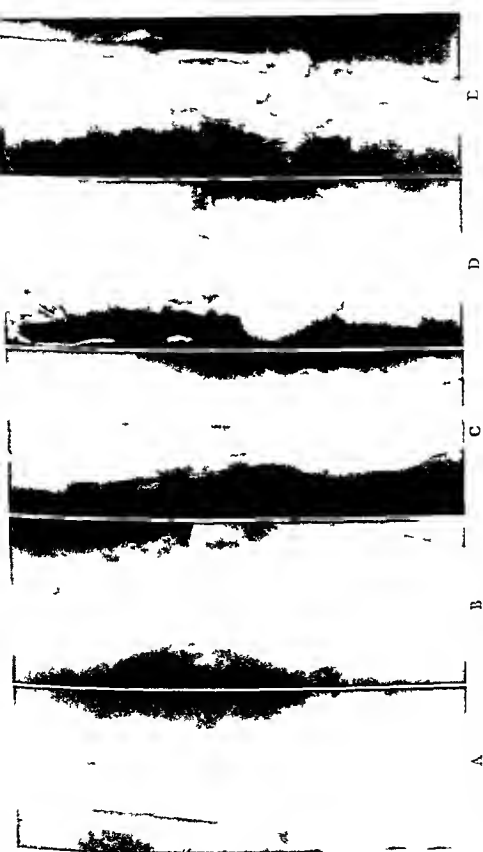


Fig 494 (Case IV) —A Anteroposterior roentgenogram on entry showing extensive osteomyelitis B Lateral roentgenogram on entry showing extensive osteomyelitis C Roentgenogram injection with skiodan shows multiple sinus tracts D Anteroposterior roentgenogram six months after entry E Lateral roentgenogram six months after entry

fusions of blood special diets sulfonamides and other measures the patient rapidly improved. The pain disappeared his temperature dropped to normal and he gained weight. There was considerable drainage but it was not until ten weeks later that his condition warranted repetition of the Orr dressing. At this time it was noted that healthy granulation had almost closed the wound. An attempt was made to visualize the old sinus tracts extending up the thigh but all had apparently closed. The partial correction of the angulation had been maintained and a moderate degree of callus was present. The decubitus about the pelvis had completely healed as had the pin holes. The wound was repacked and another unpadded long leg cast applied. Within a week the patient was up in a wheel chair and within three weeks partial weight bearing was permitted. During the next month his cast was broken and whirlpool baths ultraviolet light treatments and progressive motion of the joints were instituted (Fig 494 D E).

This case beautifully illustrates the importance of postural (gravity) drainage in the presence of extensive infection in the soft tissues. The patient was gravely septic and his condition became progressively worse until the head of his bed was raised so as to place the level of the hips above that of the knees. Immediately following this change of position there was a marked increase in the drainage of pus from the wound and a parallel improvement in the patient's general condition. Within a few weeks the extensive sinus tracts throughout the thigh had disappeared.

SUMMARY

Four representative cases of compound fracture sustained in enemy action about the Solomon Islands have been selected from a large series studied. Space does not permit a detailed account. It has rather been our idea to present typical case histories from which to draw a few pertinent conclusions. Comments have been made at the end of each case so that only a brief summary is given here of some of our observations in the care of war injuries.

1. The interval between injury and definitive treatment remains all important. In our series this interval varied between twenty five minutes and three weeks. Such variations can be

understood by recalling our war correspondents' accounts of the conditions during enemy action. In short the wounded man may be taken immediately to safety or he may lie wounded in the jungle undiscovered for days or weeks. All war wounds are considered infected and are treated as such, yet it follows that the shorter the interval between injury and treatment the more likelihood there is of a better end result.

2 The administration of morphine in half grain doses on the field has added immeasurably to the comfort of the injured during many instances of tedious and back breaking evacuation to the field hospital.

3 The great value of sulfonamide implantation as well as sulfonamide by mouth is known and need not be stressed. In the later treatment of fractures in which osteomyelitis develops the authors have been impressed with the better response of the wound to a mixture of sulfanilamide and zinc peroxide under the vaseline pack than to sulfanilamide alone.

4 Nothing can be added at this time regarding adequate definitive treatment over that already practiced in the immediate past save to suggest early internal fixation in cases such as the one illustrated by Case IV in which the prognosis is poor for effecting and maintaining reduction.

5 From our experience we advise the institution of postural (gravity) drainage immediately in all cases of injury to the thigh.

6 In the treatment of late compound wounds we believe that conservatism should be the watchword and early restitution of muscular tone the goal. We are convinced that joints may be more quickly rehabilitated if muscular tone is maintained by various exercises while the joints are immobilized in plaster. The cooperation of the bed patient in this regimen is difficult to obtain but the increased function of the part repays his efforts. Maintenance of muscular tone is readily realized with early weight bearing in a cast with a walking iron and for fractures of the humerus by the use of a hanging cast with early institution of pendulum motions.

7 The value of whirlpool baths using soapy water is pointed out as another means of speeding the healing of wounds. In addition small doses of ultraviolet light are beneficial.

8 In Case II the progress of phagedenic ulceration of the

fusions of blood special diets sulfonamides and other measures the patient rapidly improved. The pain disappeared his temperature dropped to normal and he gained weight. There was considerable drainage but it was not until ten weeks later that his condition warranted repetition of the Orr dressing. At this time it was noted that healthy granulation had almost closed the wound. An attempt was made to visualize the old sinus tracts extending up the thigh but all had apparently closed. The partial correction of the angulation had been maintained and a moderate degree of callus was present. The decubitus about the pelvis had completely healed as had the pin lines. The wound was repacked and another unpadded long leg cast applied. Within a week the patient was up in a wheel chair and within three weeks partial weight bearing was permitted. During the next month his cast was bivalved and whirlpool baths ultraviolet light treatments and progressive motion of the joints were instituted (Fig. 494 D E).

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REHABILITATION OF THE BURNED HAND*

LT COMMANDER J MINTON MEHERIN

and

LT COMMANDER PAUL W GREELEY

Med cal Corps United States Naval Res •

IN spite of the excellent progress made in recent years in the active treatment of early burns, the initial insult to the affected tissues leaves much to be corrected after the original lesions have healed. Superficial burns of course present practically no sequelae. However, when the damage is of sufficient magnitude to cause deeper destruction the late complications are all in proportion to the depth of the injury. Deep second degree and third degree burns leave results that are peculiar in themselves. When these burns occur in the hands where highly kinetic structures are involved the complications frequently leave alarmingly serious after effects.

Since it has been our fortune to see many lesions involving the extensor surfaces of the hands we would like to present our experience in the management of some of the typical cases in this group.

The majority of the burns in this series have occurred as a result of the flash from exploding bombs of burning oil being thrown upon the hands while still aboard ship or after having abandoned ship. The survivor has been burned by the ignited oil floating on the sea or in coming to the surface has had the misfortune to emerge through an area where oil is burning.

The mechanism of these burns readily accounts for the fact that most of them are on the dorsum of the hands. In the case of the bomb flash the normal reflex is to protect the most ex-

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posed parts with the palms of the hands. In performing routine duties aboard it is obvious that the dorsal and not the palmar surfaces of the hands will be exposed most often to a burning spout of oil. As the submerged survivor comes to the surface the natural movement is to thrust the upper extremities above his head from the vertical to the horizontal with the dorsal surfaces outward.

Treatment of these burns during and immediately after action must be on a wholesale basis. Nevertheless it should be stressed here that no matter how great the experience of the attending surgeon the prognostication of the depth of any fresh second or third degree burn is an impossibility unless the tissue destruction is so massive as to leave no doubt. Therefore it would be wise to treat all such burns as severe third degree types until they are proved otherwise.

SYMPTOMS

Injuries following first degree burns need no comment since they all heal without any resulting deformity. The same applies to the more superficial second degree type. However those following deep second degree and third degree burns will always produce varying degrees of disability.

The healed deep second degree burn is scaly and dry and the skin has lost much of its elasticity. Since the burns we wish to demonstrate in this clinic are all on the extensor surface of the hands and fingers, one notes a marked limitation of finger flexion due to the tough dorsal covering. Forceful attempts to flex the fingers causes the skin to crack and break down over the metacarpophalangeal joints. The circulation has been impaired to a degree that in cool weather the hands become cyanotic and tingle. They are abraded easily and the wounds heal slowly.

The healed third degree injury causes varying degrees of deformity depending upon the depth of destruction. It is not uncommon to see fixation of the digital and metacarpophalangeal joints because of dense periarticular fibrosis and fibrous union between the extensor tendons and underlying bone. In fact the tendons in some cases have been lost completely because of the depth of the burn. All of this deep scarring tends to dorsiflex the metacarpophalangeal and digital joints because of its natural tendency to contract.

GROSS PATHOLOGY

Except for some temporary hyperemia, very little gross change is noted in the more superficial second degree burn. The deeper lesions of this degree, however produce many fibrotic changes

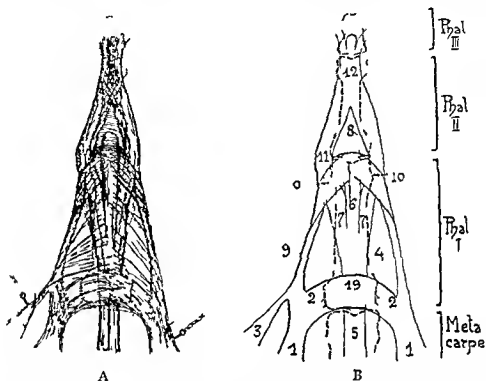


Fig 495—A Drawing showing the extensor apparatus of the middle finger from the dorsal surface. The lateral muscles and their tendons have been pulled aside and dorsalwards to bring them into the same plane as the extensor tendon and to show the fan shaped fibers which connect them.

B—1 Interosseus muscles at the point where they give off their tendons. 2 Dotted lines show the relations of the interosseus on the ventral surface. One sees their insertions into the lateral tubercles of the base of the phalanx. 3 Lumbrical muscle and tendon. 4 The fibers of the fan. 5 The extensor over the head of the metacarpal. 6 Median slip of the extensor apparatus. 7 Lateral slips of the extensor apparatus. 8 The triangular area between the lateral slips. 9 The interosseous lumbrical tendon. 10 Spiral fibers over the region of the proximal phalangeal joint. 11 The lateral bands. 12 Tendon to the distal phalanx. 19 Insertion of the extensor tendon at the base of the proximal phalanx. (From Montant R and Baumann A. *Ann d anat path* 14(4).)

throughout the skin substance. The skin covering is dry, scaly and avascular. There is little or no damage to the subcutaneous fat pad.

box and razor technic. The resulting graft is the same by either method but the factors determining the choice of procedure are guided chiefly by the operator's individual skill and experience.

Third Degree Burns—Third degree burns produce more complicated problems. In the early stages a thin Thiersch graft should be applied as soon as clean granulations are obtained. This will promote rapid healing and at the same time convert the open area into a closed wound. It will also prevent the formation of the amount of scarring that one sees when the lesions are permitted to fill in with scar epithelium by secondary intention. It must be remembered however that the Thiersch graft is to be looked upon as a temporary covering and that as soon as it seems advisable it should be excised and a permanent skin graft applied.

When tendons are exposed as a result of loss of the normal fat pad the defect must be covered with a well chosen skin flap which carries a fat pad with it. This will serve to give protection to the gliding mechanisms beneath. A glove type of flap from a hairless area on the abdomen is usually chosen for this purpose.

In case of extensive damage to tendons, joints and bone one must frequently compromise in making a selection of the skin replacement. This is done because of the fact that the depth of destruction has produced permanent damage to the tendons and joints below to such an extent that any future return of their function seems unlikely. Consequently covering with a single thick split thickness skin graft will give an adequate covering and at the same time be much simpler to manage. However if subsequent reconstruction of the tendon and joint injury is anticipated a flap with its subcutaneous fat pad must be used for the replacement covering.

Tendon and Joint Repair

Unfortunately in those cases in which tendon repair or transplantation was indicated the periaricular and articular damage has been so great as to preclude the possibility of success.

Various types of traction to the fingers with and without active motion, intermittent splinting and so forth have at the late date when these cases have come under our care not yielded

any brilliant results. In general the most marked improvement has been won with supervised active exercises.

As stated previously the dorsal extensor apparatus has been injured in many of the cases of this group with a resultant flexion of the proximal phalangeal joint, and hyperextension of the distal joint. At the time that the skin graft is done these joints and the remaining parts of this apparatus should be carefully inspected. Even though the loss of the aponeurosis is extensive longitudinal incision extending through the capsule over the dorsum of the proximal phalangeal joint with plication of the capsule in the same direction should be considered. Even in the face of almost irreparable damage of this mechanism the procedure may allow some flexion to take place at the distal phalangeal joint. This is of the utmost importance for if some flexion is gained then some of the finer movements can be performed between the involved digits and the thumb.

The immediate repair of tendons partially or completely destroyed by a burn is of course an impossibility. At the end of six to ten weeks dense scar tissue has been laid down and the subcutaneous fat pad has been to a greater or lesser extent depleted. The problem then is to cover the part with pliable skin before tendon repair can be considered.

It is generally agreed that after two months severed or destroyed ensheathed tendons should be replaced by tendon grafts. This is especially true if the lesion lies distal to a fibrous or fibroosseous tunnel. The performance of tendon transplantation requires absolute adherence to several fundamental *surgical principles*.

- 1 The field must be bloodless. This is accomplished by complete elevation of the extremity for forty seconds followed by the rapid inflation of an efficient blood pressure cuff to 250 mm of mercury while the extremity is still elevated. Some operators prefer to elevate the part and wrap it with an Esmarch bandage to within 1½ inches of the blood pressure cuff and then to remove it after the cuff has been inflated.

- 2 The technic must be atraumatic from start to finish. Pulling, tugging, blunt and gauze dissection will not be tolerated by these tissues.

- 3 The structures should be exposed proximal and distal to the lesion proceeding always from the normal to the patho-

logical Attempts to identify the injured structures at the site of the lesion are always difficult and may well lead the operator into confusion and the further damage of tissues

4 If the tendon or tendons involved pass through fibrous or fibro osseous canals those canals if obliterated must be reestablished if the procedure is to be successful This is usually best performed by the use of the proper size tendon stripper Here the operator must approach from normal toward pathological tissue

5 If a tendon graft is to be used care should be exerted to see that paratenon or a substitute for it is included in the graft Substitutes for paratenon may be cut from various fascial surfaces (triceps etc.) and the moist glistening surface sutured loosely about the tendon transplant to restore the gliding mechanism These transplants are better than fat unless fat can be mobilized at the site Howard¹ has shown that tendons possess an internal endothelial lubricating apparatus maintaining the pliability and suppleness of the moving part

6 The grafts should be obtained from the more readily available sources such as the long extensors of the toes which may be sacrificed with but negligible interference with function The palmaris longus tendon may also be used

7 The suture material of choice is No. 34 or No. 35 stainless steel wire and the pull out wire suture is described by Bunnell has very definite advantages Paraffinized silk gives unfavorable tissue reactions and its use should be avoided especially in tendons which lie superficially

8 The pulley apparatus should be preserved wherever possible If it has been destroyed it must be reconstructed from fascial strips These should be inserted where necessary through small drill holes in the bone and so fastened as to form a sling for the reconstructed tendon

9 Following tendon repair the part should be splinted in the moderately relaxed position and early motion within the limits of the retaining apparatus should be encouraged

Several details in the above procedures should be stressed The tourniquet having served its purpose should be removed from the extremity and from the vicinity of the operating table Too often a loosened tourniquet is not completely deflated and the consequent venous stasis may result in the complication

of a postoperative hematoma Pressure dressings be they of sea sponge, machinist's waste, or gauze fluffs, should always be applied with the extremity elevated The incisions should be covered with a greasy dressing to allow early active motion

Constant postoperative elevation of the extremity should be insisted upon Flexor tendons are kept immobilized for three weeks extensor tendons for from four to six weeks Postoperative physiotherapy is an important adjunct but it is far more important to educate and encourage a patient to perform persistently those movements which will restore function most rapidly This can be done by giving him occupations and duties which he enjoys doing

REPORTS OF CASES

To demonstrate this discussion, we wish to show you the following cases which are representative of the points which are under consideration

CASE I—This patient is a Chief Storekeeper whose hands were badly burned by flaming oil on December 1 1942 Upon admission here one month later the hands were covered with spotty granulations The extensor tendons were exposed over the metacarpophalangeal joints There was almost complete loss of motion of the intrinsic muscles and only coarse movements were preserved X ray films (Fig 496 B) showed diffuse low grade osteomyelitis with sequestra formation

One month after admission a persistent granulating defect over the dorsum of the right hand was covered with a Thiersch graft to convert it into a closed wound (Fig 496 A) Subsequently small sequestra have continued to be extruded from time to time

Since this is a very severe case we do not feel that operative interference will be of any practical aid With the help of physiotherapy consisting of whirlpool baths massage and exercises slow improvement in function is developing However much of this motion is transmitted through the scar tissue itself

CASE II—This young man is a Fireman second class who was injured on December 1 1947 when his ship was struck by an enemy torpedo A spout of flaming oil fell upon him and ignited his clothing His most serious burns involved the extensor surfaces of both hands and fingers After receiving local treatment he was sent back to a base hospital A granulating defect developed on the dorsum



Fig 496—A Severe second and third degree burns after three months
B Recipient of left hand also The dorsal cortical surfaces of the middle



Fig 497—*A* Six months after the burn The middle finger shows the characteristic deformity which occurs following destruction of the dorsal extensor apparatus The proximal phalangeal joint is flexed and the distal phalanx is extended *B* Anteroposterior roentgenogram of a severe second and third degree burn of hand three and one half months after injury Note moderate bone atrophy and only slight narrowing of the joint spaces

phalanges are exceedingly dense Only minor sequestration occurred *C* The same hand ten weeks later The cortical surfaces are less dense Observe the typical deformity of the middle finger with dislocation of the distal phalanx

of each hand due to a third degree burn. These areas were covered with thin Thiersch grafts to convert them into closed wounds. The grafts grew well and active motion of all hand and finger joints was started six weeks after his initial injury.

The patient was admitted to this hospital approximately eleven weeks after his accident. At that time the hands were well healed but there was marked limitation of motion because of the fibrotic covering and periarticular fibrosis. A prolonged course of physiotherapy was instituted including traction and active motion, but with very little gain in function. In addition we note a dorsal extension (Fig 497 A) of the terminal phalanx of the middle finger.

After three months of conservative therapy it was decided that these hands should be operated upon. Accordingly the left hand was treated first. Under 1 per cent procaine local infiltration anesthesia all of the scar was excised from the extensor surface leaving all undamaged underlying veins and subcutaneous fat. Hemostasis was secured by ligation with No. 50 white cotton thread.

We next explored the dorsal extensor apparatus of the middle finger and found it was partially destroyed. The dorsal surface of the capsule of the proximal phalangeal joint was opened longitudinally following which it was pliated in the same direction. This permitted the patient to flex his distal phalanx to approximately 25 degrees a range of motion which is still retained.

We next cut a single massive thick split skin graft from the right side of the lower abdomen. The graft was cut to approximately 85 per cent of the total skin thickness and was removed with the Padgett dermatome. The graft was next placed over the hand and finger defects and sutured in place with black cotton stitches. Flat pressure dressings were next applied and the hand immobilized on a straight padded board splint for two weeks. A perfect take ensued and daily soakings in warm soapy water accompanied by active and passive motion were started on the fifteenth postoperative day. All dressings were removed permanently at the end of three weeks and physiotherapy was continued.

Two months after the first operation the right hand was operated upon and the same procedures followed except for the tendon surgery which was not indicated on this side.

While a perfect result cannot be attained because of per articular joint fibrosis marked improvement is already apparent. The skin covering is soft and pliable and additional physiotherapy and occupational therapy will aid in loosening further the stiffness about the joints. The return of flexion of the terminal phalanx of the left middle fingers is of great aid in the usefulness of this digit.

CASE III—This lad is a Fireman second class who was also burned on December 1, 1942 when his ship was struck by an enemy torpedo. Flaming oil struck the dorsal surfaces of both hands but chiefly the right. This was a very deep second degree burn that healed spontaneously under sterile vaseline gauze dressings. Subsequently a very large amount of fibrosis developed in this burned covering (Fig 498 A, B). While little contracture developed the covering abraded easily upon the slightest degree of trauma. Furthermore the covering became very cyanotic when he went out of doors in cool weather. These complications of course arose because of the poor capillary circulation in this cicatricial like skin.

Because improvement did not become apparent after a prolonged course of physiotherapy, the tough fibrotic covering was excised. Upon removal we found that this damaged tissue averaged well over $\frac{1}{4}$ inch in thickness and was completely devoid of any semblance of elasticity.

As with the foregoing case we chose to cover the resulting cutaneous defect with one large massive thick split skin graft. As a good subcutaneous fat pad was present, there was no indication for utilizing a pedicle flap. Furthermore our experience has proved that these thick split thickness grafts function as well as and are at the same time much simpler to handle than free full thickness skin grafts.

The graft was cut from the lower abdominal wall with a Padgett dermatome. After securing the graft to its bed pressure dressings were applied and maintained for two and one half weeks. Following postoperative physiotherapy an excellent result has been obtained (Fig 498 C, D). The new covering is elastic soft will withstand considerable trauma and will not show the circulatory disturbances when the patient works out of doors in cold weather.



B



D

Fig 498
1664

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Fig 498 (Case III)—A B A thick hypertrophic scar is evident following healed deep second degree burn Note ulceration on dorsum of right hand C Six weeks after excision of all fibrotic covering and replacement with massive split thickness graft on dorsum of right wrist hand and fingers The left hand has not yet been grafted D Same as C right showing full function of fingers

CARE OF THE INJURED IN COMBAT ZONES*

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THE evolution of military surgery is definitely related to the weapons of war. Prior to the introduction of firearms and gun powder in the fourteenth and fifteenth centuries the methods of treatment had been the same from time immemorial. Most injuries were the results of swords, arrows and clubs. With the advent of destructive weapons the problem of surgery became more complicated. In the Napoleonic wars the handicap was considerable, while surgical technique was advancing rapidly the science of surgery was lagging behind. Baron Larrey, Surgeon General of Napoleon's army treated wounds on the field of battle, amputated limbs, removed bullets, trephined the skull and performed tracheotomies but the patient had to pass through the dreadful drama of operation without anesthesia. At that time anesthesia, antiseptic surgery and the science of bacteriology were not known and the mortality was appalling.

Today with modern warfare new weapons have been added and as a result the number of injuries has increased and our surgical problems have increased accordingly. The high velocity bullets, powerful and destructive artillery, machine guns, grenades, bombs, mines and torpedoes have increased the number of wounds and compound fractures. The air raids increased the number of casualties especially crushing injuries and atmospheric blast injuries not only on the field of battle but among civilian population as well. Submarine warfare in its destruction of merchant vessels brought the immersion foot syndrome in addition to other injuries and the depth charge to counteract the submarine brought the immersion blast injuries.

The incidence of burns in this war has been increased con

*The opinions or assertions contained herein are the private ones of the writer and are not to be construed as official or reflecting the views of the Naval Department or the naval service at large.

siderably by the flash burns of high explosives by flame throwers and as a result of men swimming in a sea covered by flaming oil from sinking and burning ships. This is in addition to the innumerable burns caused from steam gasoline phosphorus and electricity.

The mortality rate among wounded Naval and Marine personnel in the Pacific area is about 2 per cent. Probably the most important factors contributing to this low rate are plasma sulfa drugs and early air transportation of the seriously wounded to mobile base hospitals behind the battle lines hundreds of miles away. Thus the fundamental principles of surgery are applied promptly in the field and aboard fighting ships. Air transportation permits early definitive treatment in base hospitals and hospital ships; however persons with cranial and thoracic injuries should not be transported by air at high altitudes and abdominal wound casualties should not be transported for a period of about ten days after the injury.

The front line in modern warfare is so highly motorized that frequent and rapid shifting of the battlefield should be expected. Progression of troops in jungle fighting is much slower than on other fields of battle where the wounded are scattered over a large area. Under such conditions the time consumed in collecting the wounded offers a serious handicap to prompt and ideal treatment. In combat zones the majority of injuries are wounds, burns and compound fractures and sometimes a combination of the three. This is true especially in naval battles when bombs explode below decks. To these injuries are added concussion, blast and asphyxiation from gas and smoke.

SURGICAL PRINCIPLES

The surgical principles involved in the treatment of war wounds, burns and compound fractures are similar. They are

- 1 Administration of morphine
- 2 Prompt arrest of hemorrhage
- 3 Treatment of shock by administrations of plasma
- 4 Conversion of a contaminated wound into a clean wound by débridement and chemotherapy
- 5 Application of a simple practical dressing
- 6 Immobilization of fractures
- 7 Placing the injured at rest

- 8 Preparation of the patient for transportation to a base hospital when his condition permits

In the military service it is not only the best method of treatment which must be considered but one which permits treatment of a large number of casualties in a limited time. This is especially true in the treatment of burns. Two hundred and fifty four patients with burns were admitted to the Naval Hospital at Pearl Harbor within a period of three hours. This accounted for about one half of the wounded who were admitted to the hospital. Under such circumstances any elaborate and time consuming preparation of the burned surface would be out of the question. The same principle applies to the treatment of fractures. A satisfactory method is one that is simple to apply, gives satisfactory fixation, allows the patient to become ambulatory in days instead of months, facilitates the transportation of the patient, requires a minimum amount of nursing care, is reasonably comfortable and permits early active motion.

SHOCK

In combat zones there are many factors that predispose to and aggravate shock—factors that are seldom seen in peacetime. Fear, anxiety, exposure to cold or heat, dehydration, hunger, long hours of duty and lack of rest are important contributing factors in war. Not infrequently one sees a man only slightly wounded in battle who is suffering from shock. In the light of these facts it is important for the medical personnel to be able not only to recognize shock but to recognize it in its impending and early stages. Laboratory methods are not available on the battlefield and there and aboard ship in time of action diagnoses should be made on the clinical findings only. Any change from the normal that becomes progressively worse should be a sufficient warning of impending danger.

PROPHYLAXIS

Prophylactic measures should be employed whenever and wherever possible. Past experience has shown us that various types of vaccines are of considerable value. The general administration of *tetanus toxoid* to the troops when inducted into military service is of great worth. Not a single case of tetanus has been reported from the Pacific area.

Life jackets are useful to protect chest and abdomen against immersion and blast injury. The *steel helmet* is used for the prevention of cranial wounds. In the French army the incidence of this type of wound was reduced from 15 to 3 per cent by its use. *Plastic material* is being employed by the Germans as a protection against abdominal and thoracic wounds. The physical prophylaxis of wounds was practiced not only by the Romans but by many armies of ancient time. At present considerable interest and study are being directed to that field for the improvement and advancement of this type of prophylaxis.

IMMERSION FOOT SYNDROME

The survivors of torpedoed ships who drift for days and sometimes weeks develop a painful edema of the extremities. This syndrome is often referred to as immersion foot. It is similar to trench foot of the last war which was caused by long standing in the mud and cold water of the trenches. White believes there is a clinical and etiological difference between the immersion foot syndrome which so often develops in the survivors of vessels torpedoed in the colder waters of the North Atlantic and those in the South Atlantic. The former is characterized by painful edema of the extremities which in severe cases is associated with vascular thrombosis, thermal injury to peripheral nerves, frost bite, sepsis and sometimes gangrene. After removal from the cold, an intense inflammatory reaction develops with reactive hyperemia and in some cases blisters, petechial hemorrhages and impaired circulation develop. This syndrome is probably caused by thermal injury, dependency and immobility of the feet and legs, prolonged dehydration, malnutrition, hypoproteinemia and vitamin deficiency, especially B and K.

In *treatment* it is important to determine the degree of dehydration, hypoproteinemia, avitaminosis and electrolyte balance and restore these deficiencies to normal level. The local treatment consists of elevation of the extremity and gradual elevation of temperature.

IMMERSION BLAST INJURIES

Injuries sustained as a result of detonation of high explosives under water were given the name of immersion blast by Rex

Williams, R N The critical distance from the center of the detonation of high explosive in the air is about 20 feet and under water it is 80 feet Sound waves in the water travel four times as fast as in the air Severity of the injury depends on severity of the high explosive the distance from the center of detonation and the position of the individual in relation to that center

Palma and Uldall in reporting thirty five casualties of immersion blast injuries pointed out these facts

About ten to forty five minutes after the explosion the ones who were facing the blast or swimming in the prone position began to develop abdominal symptoms varying in degree from mild fleeting cramps to severe continuous abdominal pain Several vomited and developed diarrhea all developed a sense of thoracic compression and many had hemoptysis lasting from twelve to twenty four hours The group that had their backs toward the blast or who were swimming in the supine position developed similar abdominal symptoms but to a lesser degree than the other group and their signs and symptoms were in the chest One of these patients relates an interesting story He had been swimming toward a raft accompanied by two of his buddies Tired by his exertions he had turned over on his back to rest for a moment One companion who had reached the raft first was climbing aboard it the second a few yards behind was still swimming in the prone position At this moment the underwater explosion occurred about 150 feet distant His companion on the raft suffered no injury the other was killed immediately

Most of the survivors were stunned many were unconscious several lost temporary sensation in their legs and others had the urge to empty the bladder and rectum

Abdominal trauma varied in severity from moderate multiple small hemorrhages in the intestines and mesentery to severe perforations and lacerations Rupture of liver and spleen was not noted Changes in the lungs were constant but not very severe

In atmospheric blast injuries the principal seat of trauma is in the thoracic cavity In immersion blast injuries the predominating and urgent pathology was found in the abdomen and to a lesser degree in the bases of lungs While lungs are more susceptible to the immersion blast injuries than the intestinal tract this did not prove to be the case among the survivors of the

Midway Battle suffering from this condition. The life jacket was undoubtedly the protective agent without it the injuries would have been more severe in the chest. This was proved by the experimental work of Greaves and his associates. They stated: "The presence of gas or air in the tissues is the determining factor in the production of underwater blast injuries. Pathological changes were not observed in solid organs and in tissues that do not contain air or gas." Friedell and his co-workers in their experimental work on immersion blast reached a similar conclusion.

Treatment in these cases should be conservative: absolute rest, oxygen and plasma if indicated, abdominal decompression by means of continuous suction and sedatives in moderation. These patients should be carefully watched and surgical interference if it is indicated should be undertaken without delay.

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THE USE OF THE COAGULUM CONTACT METHOD IN SURGERY*

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THE present article concerns the use of a physiologic adhesive medium for the attachment of skin grafts and the adhesion of cut surfaces of internal organs such as the liver without the use of sutures. The method has likewise been used for the promotion of primary healing in open granulating or septic wounds.

PRINCIPLES AND TECHNIC

A brief exposition of the principles upon which the coagulum contact method is based and the technic of preparing the adhesive coagulum used is essential to an adequate presentation of the clinical cases to be described illustrating the feasibility and the potentialities of the new procedure.

Method of Preparing the Two Elements Which When Brought Together Develop a Fibrinous Adhesive Coagulum Simulating in Intensified Form the Normal Adhesive Process Occurring in Wounds

Into a syringe containing 1 mg. of heparin (or equivalent units which will prevent 5 cc. of blood from clotting for twenty-four hours) dissolved in 1 cc. of Tyrode's solution† (a buffered salt solution) 5 cc. of the patient's blood are drawn under sterile conditions. The blood is centrifuged and the plasma pipetted off into a sterile tube. This constitutes *solution A*. The leukocytic film overlying the erythrocytes (the buffy coat) is removed with a platinum loop and placed in another sterile tube containing 3 cc. of Tyrode's solution and three sterile glass

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† Sodium chloride 0.800 potassium chloride 0.010 calcium chloride 0.020 magnesium chloride 0.010 monosodium phosphate 0.005 sodium bicarbonate 0.100 glucose 0.100 and water to 100.

beads By shaking the buffy coat with the Tyrode's solution and glass beads the cells are broken down forming the desired cellular extract This suspension *solution B*, also may be referred to as leukocytic extract or simply cell extract The cellular debris in this solution does not interfere with the surgical operation and is retained The procedure differs from that used in tissue culture as in the latter it is necessary to centrifuge the suspension and use only the supernatant fluid

As Applied to Skin Grafting

The *coagulum contact method* is adapted to the adhesion of Thiersch grafts split skin grafts and full thickness grafts Preparation of the recipient area and the removal of the graft is very similar to that in other grafting methods The recipient area must be clean and healthy If it has a surface of granulation tissue this is washed with hot saline solution and dried before grafting If on the other hand it is freshly denuded excessive bleeding must be stopped Fine silk or better alloy steel wire sutures may be used for tying the vessels alloy steel wire offering less interference than catgut or even silk to a perfect adhesion If there is only slight oozing the application of hot saline compresses is usually sufficient or the bleeding may be controlled by the hemostatic action of the coagulum If the graft is removed with a razor or scalpel and is to be placed on a large granulating area where perfect fitting of the edges is not required no special precautions as to oversize need be taken If an exact fit is desired the graft should be cut larger than the recipient area and fitted When the Padgett dermatome is used little contraction takes place and the graft needs to be only slightly larger than the area to be covered

The skin graft after removal is never left in saline solution or moistened but is placed upside down on a piece of gauze or left on the dermatome if the latter has been employed The plasma (solution A) is applied with a sterile camel's hair brush over the recipient area and the extract (solution B) is painted on the under side of the graft which is then gently fitted to the recipient area Good contact is assured and air bubbles or excessive fluid removed by pressing the graft down gently with forceps starting from the center and working outward to the edges This should be accomplished within three to four min

utes Once perfect contact has been established the graft should not be disturbed for fear of breaking the delicate adhesive fibrils which begin to form within a few seconds after solution A contacts solution B After five minutes gentle friction with forceps will then assure the operator of the adhesion of the graft Dressings or stitches are not used If there is danger of infection of as yet uncovered granulation tissue or if it is advisable to protect the area from the vision of the patient or from his surroundings single strips of boric acid gauze may be placed lightly over it

Within forty eight hours the graft surface turns to deep purple color due to vascularization The purple gradually becomes a healthy pink and later this fades to the normal tint of the surrounding skin Also the graft early becomes warmer than the adjacent normal skin Sections from animal grafts reveal that the small capillaries are filled with apparently normal erythrocytes

As Applied to Wounds of the Liver and Spleen

The preparations used are preferably autogenous media A and B the same as in skin grafting Before use however each of the two solutions is distributed in several sterile tubes so that a number of tubes may be available to prevent contamination and premature fibrin precipitation in the tube through contact with tissue juices and fresh blood This precaution is necessary when several areas are to be painted and also applies to large areas of skin grafting Dried pooled plasma and buffy coat has also been successful in dogs

As Applied to Incised or Lacerated Wounds of the Skin and Subcutaneous Tissues

The wounds are prepared as for closure by suture If there is stress or tension tending to separate the lips of the wound provisional sutures are inserted to relieve the tension but not tightened until solution A has been applied to one edge and solution B to the opposite edge of the wound The sutures are then quickly tied with as little disturbance of the coagulum as possible A similar procedure may be used to affix and promote vascular union to a transplanted pedicled flap

As Applied for the Arrest of Capillary Hemorrhage

Small muscle grafts are applied over oozing areas for the arrest of hemorrhage. A more intense adhesion is obtained by coating the graft with solution B and the oozing surface with solution A. Grafts of fascia or fat may be used instead of muscle. The graft is held in place with light pressure for about two to five minutes. (On this basis the method should be applicable to many of the problems of brain surgery.)

Comment

In tissue culture³ the most frequently used solid medium is heparinized plasma usually chicken plasma and embryonic extract or spleen extract in buffered salt solution. The details of its preparation are as numerous as the individuals using the technique and are not pertinent to the present discussion. Mixed together they form a coagulum which serves both as a supportive and as a nutritive medium. The ideal preparation has an optimum pH for cell growth. It appeared logical therefore that such a medium would create a better environment for cell union of two apposed tissue surfaces which otherwise might have a tendency to slight displacement that would seriously disturb early cellular proliferation. In word possible foreign protein reaction autogenous plasma and cell extract are used. Originally the supernatant fluid extract from a mixture of red and white cells was used but unless it was centrifuged the excess of erythrocytes seemed to interfere with the take of the graft. Accordingly at present the extract prepared from the buffy coat alone and which requires no centrifugation is used.

Since the application of the method to skin grafting it has been found in tissue culture experiments that the leukocytic extract of man has growth promoting properties very similar to those found in the embryonic extract. In comparative tests of the growth promoting values of various fluids under investigation leukocytic extract was found to surpass the other stimulants of tissue proliferation except embryonic extract which it equaled. It was natural therefore to assume that it might be of some use in the healing of surgical wounds where difficulty was anticipated or in the epithelization of burns. Clinically both these premises have been confirmed in the cases to be presented. The coagulum however is a delicate structure and must not

be manipulated harshly. It is a physiologic firm jelly like growth promoting medium. It must not be considered a stick all glue. Lest the physician's phantasy attribute to it magical properties the reader must be warned against any such claims.

CASE REPORTS

The Coagulum Contact Method in Skin Grafting

Skin grafting has been performed by the coagulum contact method in twenty five cases at this hospital. The method has been used successfully in other hospitals but these cases are not included in this series. In two of the twenty five cases herein reported results were unsatisfactory, one on the frontal bone in which *Bacillus pyocyaneus* infection was present, and another a crushed finger in which culture showed a heavy growth of *Streptococcus viridans*. Of the first ten cases reported elsewhere,⁴ six were patients of Dr W Emory Burnett by whom the method was first used. The cases reported here are of especial interest, the others were routine, presented no difficulties and were also entirely successful.



Fig 499 (Case 11) —Healthy granulation tissue has replaced the infected ulcer
(Courtesy Dr J N Coombs)

CASE 11—A man aged thirty two years was admitted to the service of Dr J N Coombs on April 22 1943. A cyst located about

2 cm above the right external malleolus had been removed during the summer of 1942 the wound healed poorly and in December 1942 reopened. On admission the ulcer was deep grayish and measured about 5 cm in diameter. It was treated with zinc chloride and then bichloride solution (1:5000). On May 7, 1943, healthy granulation tissue had formed (Fig. 499) and a full thickness graft was applied on May 9, forty-eight hours after grafting the central portion of the graft was a deep purple color and by evening of the same day the whole graft was warm except for the overlapping edges (Fig. 500). On May 12 the patient was permitted to sit in a chair with his leg in a vertical position for one to two hours. On



Fig. 500 (Case 11)—Full thickness graft four days after grafting (Courtesy Dr. J. N. Coombs)

May 13 he was allowed to walk for short periods, the leg being supported with a light rubber bandage. The patient was discharged on May 16th and has been at work since he left the hospital. The graft on September 25, five months after operation, had taken on the appearance of the adjacent skin.

CASE 14—A boy aged two years was admitted to the service of Dr. G. P. Giambalvo on May 7, 1943, his left shoulder having been caught in a washing machine. After debridement the wound, though deep, healed rapidly. On June 3 it was evident that scarring of the posterior wall of the acilla would limit movements of the arm. Two split skin grafts measuring about 3 cm in diameter were

applied over the granulation tissue and the arm immobilized in a cast. Five hours later the child had worked his cast loose, and one of the grafts had been rubbed off and had adhered to the normal skin below. It was reapplied in the ward. The child who was extremely active managed notwithstanding reinforcement of the cast to loosen his arm and rub off the other graft twenty four hours later. It likewise was reapplied. Within twenty four hours the first graft was a delicate pink and within forty eight hours both grafts were warm despite these accidents. He was sent home on June 12 nine days after grafting and was seen thereafter at weekly intervals in the clinic until June 30 when he was finally discharged.



Fig 501 (Case 15) —Healthy granulation tissue on which split skin grafts were applied (Courtesy Dr J N Coombs)

CASE 15 —A woman aged thirty two years was admitted to the service of Dr Coombs on May 23 1943 for removal of a papillary tumor of the skin extending over the upper portion of the sternum and right clavicle. Excision of the growth on May 24 left a denuded area measuring approximately 10 cm in diameter. The pathological diagnosis was squamous cell carcinoma grade III (Dr A R Peale). By June 9 the area was covered by healthy granulation tissue (Fig 501) and several medium and full thickness grafts were applied. Within forty eight hours the grafted skin had become a pale pink.

(Fig 502) The area was covered with a piece of dry gauze and the patient was discharged on June 13



Fig 50 (Case 15) —Skin graft eight hours after being applied (Courtesy Dr J N Combs)

Skin Grafting in Burns

CASE 24 —A girl aged six was admitted May 1 1943 to the service of Dr G P Giambalvo having suffered a second degree burn of the back from the shoulders to the buttocks. Debridement was done on the day of admission and boric acid dressings with compression bandages applied. On the tenth day the child was febrile and the entire area was covered with pus. Transfusions were given and the burn sprayed with sulfadiazine. When the infection had cleared solution B prepared as for previous skin grafts but containing 0.5 per cent sulfadiazine was sprayed over the burned surface three to four times a day. This formed a thin film and was followed by evidence of rapid healing without the formation of undesirable scar tissue (Fig 503). (The tissue extract [solution B] used in producing a physiologic coagulum over burned surfaces also may be made from the buffy coat obtained from Wassermann negative blood of a blood bank.) On July 21 1943 split skin grafts were applied became vascularized within forty eight hours and the child was permitted to

sit up in bed. None of the grafted tissue was lost and the patient was discharged on July 27, 1943.



Fig. 503 (Case 24)—Shaded area shows the epithelized burn after treatment with solution B. Note growing skin grafts two weeks after being applied. (Courtesy Dr. G. P. Giambalvo.)

The coagulum formed on the surface of burns by the solutions used is not only a very favorable medium for epithelization but also forms a barrier to the loss of serum.

Extensive Second and Third Degree Burns with Persistent Infection—Besides Case 24 (Fig. 503) two additional cases of second and third degree burns have been treated with solution B. Epithelization was very rapid in one case which had been twenty-eight months in the hospital and had not responded to any other treatment. In the third case epithelization was good but not as rapid and the coagulum film did not form as well. Of the three cases treated, none showed retractive scarring although the burns were extensive in all.

Reattachment of Epidermal Layer in Blisters

The adhesive coagulum also may be used for the reattachment of the epidermal layer raised in the formation of a blister. This was first tried with a large blister raised by a cantharidal

plaster over an area of myositis on the thigh (Fig 504) The fluid was evacuated and the two internal surfaces painted with solutions A and B The blister re-adhered and formed a pain



Fig 504 Skin blister raised by cantharidal plaster Reaffixed and healed in place with the coagulum adhesive

less protective covering over the sensitive deeper layer of the skin and did not later become displaced The same procedure may be used for large blisters resulting from burns

The Adhesive Coagulum Closure of Wounds of Internal Organs

Twenty seven experiments have been conducted twenty four on dogs and three on guinea pigs in which the liver and spleen were lacerated or incised and the adhesive solutions used to control bleeding and promote healing

In the following case the first attempt was made to close a wound in the human liver by the coagulum contact technique

Mr C S aged fifty four years was admitted to the service of Dr W W Babcock and operated upon May 11 1943 for the removal of a lipoma between the external and internal abdominal oblique muscles and an enlarged and thickened gallbladder The liver was enlarged especially the right lobe The edge was thick and rounded the surface was yellowish granular and firm with line of fibrosis suggesting a mixture of fatty infiltration and fibrosis

To determine the pathologic process better a wedge shaped piece of liver tissue approximately 1 by 1.5 by 1.5 cm. was removed from the liver edge for microscopy. Removal of this tissue caused free bleeding from the cut surfaces of the liver. The solutions of buffy coat and plasma not being immediately available hemorrhage was partially controlled by pressure with a gauze sponge but even after twenty minutes profuse bleeding continued as soon as pressure was removed. The area was then carefully packed off from the rest of the abdominal cavity and the incised surfaces painted with a mixture of the two adhesive solutions. An attempt was made to hold a peritoneal graft which had been likewise treated with the adhesive solutions in place over the bleeding surfaces of the liver in the hope that this would control bleeding but this failed since hemorrhage was so profuse that the peritoneal graft was immediately washed away with the blood. The liver edge was then pushed back into the abdominal cavity in such manner that the surfaces of the gaping wound were in contact.

The incised surfaces immediately became adherent to each other with complete control of bleeding except for a slight trickle from the corner of the wound where apposition was imperfect. A small peritoneal graft was then laid over the wound in the liver using the two adhesive solutions. Hemorrhage was completely controlled and the abdominal wound was closed with a small metal suction (sump) drain connected with an aspirator in place along the bed of the gallbladder as an indicator for further hemorrhage or bile leakage. With no further occurrence of hemorrhage the drain was removed at the end of thirty six hours. The patient's recovery was uneventful. He was allowed out of bed on the fifth day and was discharged from the hospital on the ninth postoperative day.

Histological examination of the piece of liver removed for biopsy showed the parenchymal cells to be edematous and their cytoplasm granular. The nuclei of the cells varied in appearance some being large and swollen others showing definite glycogenic changes. Throughout the parenchyma there was an infiltration of small round cells and neutrophils. In addition to the parenchymal changes there were marked vascular changes, the walls of the vessels being thickened and the lumen narrowed. Surrounding these vessels were large areas of fibrosis. A diagnosis of infectious hepatitis was made.

Résumé of Experiments on Dogs and Report on Histological Findings—Mongrel dogs were anesthetized by the intravenous administration of sodium pentobarbital $\frac{1}{2}$ gram per kilogram of body weight. The abdomen was opened through a midline or left mid rectus incision and the spleen or a selected lobe of the liver was partly delivered through the incision while the remainder of the abdominal cavity was walled off with gauze. Triangular portions of liver or splenic tissue were then excised with knife sections being made through the entire thickness of the lobe. The sections removed varied in size from 0.5 by 1 cm to 2 by 3.5 cm. In all cases removal of these portions of liver or splenic tissue produced profuse hemorrhage; in many cases vessels were seen to be spurting blood



Fig. 505 (Dog 3) —Arrows point to site of removed wedge of liver tissue three days after control of hemorrhage by the coagulum-contact method.

under low pressure. The two adhesive solutions (A and B) were then thoroughly mixed in equal proportions and liberally applied to all cut and bleeding surfaces. These surfaces were then firmly pressed together and held from two to four minutes. In all cases where this was done control of hemorrhage was immediate and complete, the cut surfaces being held firmly together by the coagulation of the adhesive mixture that had been applied (Fig. 505). This seemed all the more remarkable when one considered the tension which tended to pull the surfaces apart for a wedge of tissue had been removed and it was therefore necessary to fold the lobe of the liver in order to bring the cut surfaces together. This was sometimes accomplished with some difficulty, especially in cases where sections more than 1 cm wide were removed. Yet in no case

did these surfaces pull apart nor was any sign of recurrence of hemorrhage found at the time of reoperation from forty-eight hours to two weeks later



Fig 506 (Dog 2)—A, Spleen three days—dog B Liver three days—dog Arrow on extreme right shows site of removal of portion of splenic tissue measuring by .5 cm Note infarction three days after treatment with coagulum adhesive.



Fig 507 (Dog 2)—Four incised and lacerated wounds in the dog spleen seven days after control of hemorrhage by the coagulum-contact method

Control procedures were carried out in a similar manner except that no adhesive solutions were used. It was possible to control hemorrhage by pressing the bleeding surfaces together but it was necessary to keep the surfaces pressed together for a longer period of

time (that is until blood clotting was complete) and in no case did the line of union appear to be as firm as in the cases where the adhesive solutions were used the surfaces tending to pull apart.

Similar procedures were carried out in a number of guinea pigs and similar results obtained except that in the control animals it was found more difficult to control hemorrhage without the use of the adhesive solutions. One animal in which the solutions were not used was found dead of intraperitoneal hemorrhage after several hours due to leakage of blood from the cut surfaces of the liver.

Twenty-four hours to nine days after the original operation the abdomen was reopened the liver and spleen (Figs 506 and 507) inspected and sections taken for microscopic study. The abdomen in all cases was found to be free of blood and no increased tendency toward adhesion formation was noted. The wounds in the liver were found to be faint linear scars which became difficult to find at the end of two weeks. In the control cases the scars were more marked.

HISTOLOGIC FINDINGS IN GUINEA PIGS AND DOGS

(Hematoxylin and Eosin and Masson's Stain)

With Coagulum Mixture	GUINEA PIGS	Without Coagulum Mixture
The blood is trapped in fibrin web at the edge. There is good adhesion (Fig 508).	24 hours post operative	There is poor adhesion and complete separation during removal.
Findings are the same as above. There is an infiltration of a few leukocytes (Fig 509).	48 hours post operative	
Young fibroblasts appear in the coagulum. The adjacent liver cells are normal. There is no necrosis (Fig 510).	Dogs 3 days post operative	Young fibroblasts appear in the coagulum. There is fatty degeneration of the adjacent liver cells and focal areas of necrosis (Fig 513).
Well organized granulation tissue. The erythrocytes are found in large new formed spaces lined by a flattened epithelium. The adjacent liver cells are normal. There is no necrosis (Fig 511).	7 days post operative	Well organized granulation tissue. Many of the erythrocytes are packed together in the liver tissue. There is fatty metamorphosis and there are small areas of necrosis (Fig 514).
Very similar to the sections seen at 7 days but phagocytes laden with hemosiderin are prominent (Fig 512).	9 days post operative	Same as above with some what better organization (Fig 515).



Fig 508 (Guinea pig) —Liver from which a 0.5 by 1 cm wedge was cut. Histological picture twenty-four hours after treatment by the coagulum-contact technique. (Masson's $\times 75$)



Fig 509 (Dog 3) —Liver from which a 1.5 by 1 by 0.09 cm wedge was cut. Histological picture forty-eight hours after treatment with coagulum contact technique. (Masson's $\times 40$)



Fig. 510 (Dog 3).—Liver from which a slice 2.5 by 0.9 by 1.6 cm. was cut. Histological picture three days after treatment with coagulum adhesive (Masson's $\times 40$).

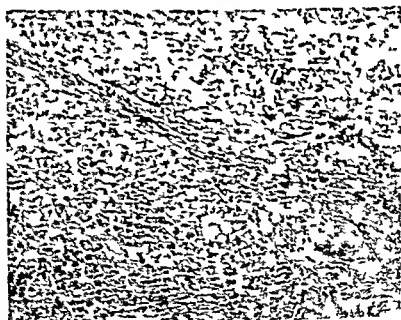


Fig. 511 (Dog 4).—Liver seven days after treatment with coagulum adhesive (Masson's $\times 120$).



Fig 512 (Dog 3) -Liver nine days after treatment with coagulum adhesive (Masson's $\times 25$)



Fig 513 (Dog 3) -Liver No coagulum adhesive has been used. Histological picture three days after operation. Compare with Fig 510 (Masson's $\times 120$)



Fig. 514 (Dog 3) —Liver. No coagulum adhesive has been used. Histologic picture seven days after operation. Compare with Fig. 511 (Masson's $\times 40$).



Fig. 515 (Dog 4) —Liver. No coagulum adhesive has been used. Histologic picture nine days after operation. Note focal areas of necrosis. Compare with Fig. 512 (Masson's $\times 120$).

Use of the Coagulum Method in the Closure of Septic Wounds

Closure of Septic, Draining Wound of Abdomen Following Operation for Carcinoma of Bowel—Miss M. L. aged fifty nine years was admitted to the service of Dr. W. Wayne Babcock on January 2, 1943 with a history of small frequent bowel movements containing blood accompanied by rectal tenesmus and loss of weight for eight months. Examination showed a slightly distended abdomen with a large palpable mass in the region of the sigmoid. Roentgen study following a barium enema several days previous to admission revealed an irregular obstructive lesion in the region of the sigmoid diagnostic of carcinoma of that portion of the bowel. At operation on January 4 a large carcinoma of the sigmoid invading an adherent loop of ileum was found and 15 cm. of sigmoid together with 30 cm. of ileum were resected. End to end anastomosis of the respective bowel ends using a one clamp aseptic technic was performed. There was a 2 mm. communication between the sigmoid and involved loop of ileum and during removal of the specimen a drop of yellowish gray fluid was seen to escape from between the adherent loops of bowel into the wound. This drop was believed to be highly infectious and was probably the etiological agent in the subsequent wound infection. A complementary cecostomy for decompression of the bowel was also performed and because it was felt advisable partially to exteriorize the sigmoidal anastomosis a large lamp chimney drain was anchored over the suture line and a sump suction drain was placed lateral to the line of anastomosis. The abdomen being closed with alloy steel wire in layers.

An ileostomy was necessary on the third postoperative day for distention unrelieved by the Levin tube with Waughensteen suction. On the fifth postoperative day several sutures were removed to afford drainage for a spreading pyoderma which had developed in the thick fatty abdominal wall. This drainage was inadequate however since the suppuration continued to spread until the abdominal wound was laid widely open down to the aponeurosis of the external abdominal oblique. On the ninth postoperative day fecal drainage was first noted from the site of anastomosis of the sigmoid, the glass lamp chimney drain having been removed several days earlier. This drainage increased until all fecal matter was discharged through the abdominal wound adding to its contamination. Surgical closure of the ileostomy opening was necessary on January 25 at which time the ends of the sigmoid were completely separated and the proximal end sutured to the skin edge.

Six weeks after the original operation an end to end anastomosis was again performed between the ends of the sigmoid using alloy

steel wire sutures. This was successful except for a residual minute fecal fistula. Meanwhile the abdominal wound had granulated slowly but still remained large, widely open and rather deep and continued to heal with gradual closure of the fecal fistula until only gas escaped. Several attempts to hasten closure by suturing the wound were unsuccessful.

The patient was readmitted to the hospital on May 10, 1943, and after the extensive granulating surfaces were sterilized with a saturated solution of zinc chloride, the wound was widely opened and all granulations and pockets curetted with a sharp curet. Persistent oozing was controlled by the application of small free tabs of fat which, with the bleeding areas, were repeatedly painted with solu-



Fig. 516—Large granulating abdominal wound following pyelotomy and colonic fistula after closure with coagulum adhesive and supporting sutures. The union was permanent.

tions B and A and the fat pressed over the hemorrhagic sites with prompt adherence and arrest of the flow of blood. The entire wound was then freely coated with the two adhesive solutions and the wound closed with interrupted No. 32 and 36 wire sutures without drainage.

The wound healed primarily without any signs of inflammation or suppuration. Twenty-four hours after operation the subcutaneous tissues were found to be markedly distended by gas and a small perforated glass drain was inserted through a small central stab wound into the subcutaneous space with the escape of gas and a small amount of serum. This glass drain sufficed to carry away the intestinal gas leaking through the small intestinal fistula which had

remained. After one week the drain was removed and no further gas accumulated. The large curved sutured wound remained entirely united with the formation of a fine linear scar (Fig 516).

Closure of a Double barreled Colostomy Following Resection of the Sigmoid and Bladder for Perforated Diverticulitis—Mr C J aged fifty years was admitted to the service of Dr W Wayne Babcock June 13 1943 with a history of an unexplained fever of several weeks duration followed by lower left quadrant abdominal pain and demonstration of a diverticulitis of the sigmoid by x ray. The patient had been given warm olive oil enemas daily for the pain until several days before admission when he began passing oil in the urine this accounting for the admitting diagnosis of diverticulitis of the sigmoid with vesicocolic fistula. There was a distinct firm abdominal mass palpable in the lower left abdominal quadrant. On admission the patient's temperature was 103° F. He had been taking sulfadiazine for more than a week and had developed a maculopapular rash over both legs therefore administration of the drug was discontinued with return of the temperature to normal within twenty four hours.

On June 15 a Mikulicz removal of the diseased portion of the sigmoid colon together with a resection of the densely adherent perforated and infiltrated dome of the urinary bladder was performed with closure of the large opening produced in the bladder. The removed portion of the sigmoid showed many diverticula one of which having perforated into the urinary bladder caused ulceration of the surrounding vesical mucosa. A collection of pus was present in the infiltrated tissue between the sigmoid and bladder. An aspirating (sump) drain was introduced to the bottom of the pelvis for continuous removal of inflammatory liquid exudate or urinary leakage.

On the fifth postoperative day signs of subcutaneous infection were evident although the general condition of the patient was very satisfactory and the wound was opened along its entire length down to the level of the external oblique aponeurosis draining a subcutaneous collection of pus. Following local treatment with wet dressings of 1:1000 bromine solution the infection rapidly subsided and the wound began to heal by third intention. When the retention catheter had been removed from the urethra and although the patient was able to pass moderate quantities of urine by urethra a urinary fistula developed between the bladder and the lower medial portion of the wound. This was proved by instilling boric acid colored with methylene blue into the bladder whereupon the colored solution immediately appeared in the wound.

The septal spur between the two loops of bowel was divided and

sutured with fine wire as a second stage procedure on June 25 and an attempt was made to close the remaining large colostomy opening on July 1 and July 9 by suture with interrupted No 36 alloy steel wire. Only partial closure of the bowel opening was obtained by these procedures and the patient continued to have fecal and urinary discharge into his wound.

On July 19 or thirty four days following the original operation the edges of the open bowel were liberated and after the serosal surfaces had been painted with the two adhesive solutions (these



Fig 517—Large granulating abdominal wound with fecal fistula closed with coagulum adhesive prepared from dried pooled plasma and extract. The union was permanent. (Supporting sutures were used.)

solutions having been prepared from dried heterologous plasma and buffy coat) the bowel opening was closed with two rows of inverting interrupted sutures of No 36 alloy steel wire. The entire wound except the urinary fistula was then freely painted with the two adhesive solutions and closed with interrupted No 36 alloy steel wire some of the sutures being placed subcutaneously others through the skin. The wound healed primarily, the granulating surfaces which had been approximated healing as though freshly cut and despite the small external urinary fistula in the otherwise healed medial portion of the wound there was no sign of infection or

breakdown in the sutured portion. No further fecal drainage occurred and the patient was discharged July 25 with his wound completely healed (Fig 517) except for the small vesical fistula which closed spontaneously within one week following discharge.

SUMMARY

1 Further evidence of the value of the coagulum contact method of skin grafting is presented and the technical details of the method are described.

2 A new method for the treatment of traumatic injuries to the liver (surgical or otherwise) is given and illustrated by one human case and twenty four experiments on animals. Histologic evidence of early vascularization is shown on microscopic section.

3 The possibility of the use of the method in wound healing is illustrated with case reports.

CONCLUSIONS

1 The coagulum contact method has given consistently good results with rapid firm healing in skin grafting.

2 The coagulum film apparently facilitates the healing of clean and infected wounds.

3 It has provided immediate adhesion and hemostasis in wounds of the liver and spleen but has been less effective in experimental wounds of the spleen.

4 It forms a protective coagulum and appears to facilitate healing of burns.

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OPERATIVE REPAIR OF COMPLETE RECTAL PROLAPSE

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THE adequate repair of complete rectal prolapse has been one of the most difficult of surgical procedures. The methods employed extend back a good many years, the earliest recorded being that of Dieffenbach¹ who in 1846 attempted a posterior wedge shaped resection for the cure of a rectal prolapse. Weinlechner² in 1883 used an elastic ligature for the treatment of prolapse.

ETIOLOGY AND PATHOLOGY

The etiology of complete rectal prolapse and the pathologic processes involved have been debated for many years. Jeannel³ in 1908 was of the opinion that prolapse of the rectum was due to a giving way of upper attachments while others claimed it was the result of a loosening of the lower rectal supports. In 1912 Moschowitz⁴ explained and propounded the idea that it was actually a sliding medial perineal hernia through the pelvic fascia. Recently Graham has devised an operation for the repair of the anatomic defect in the pelvic fascia and has given a report of three cases.

The rectum is held in position by several supports, the lower portion supported by the levator ani muscles and covering fascia which fuse in the midline with the transverse perineal and coccygeal muscles and the portion which forms the sphincters. Just above the levators and extending from the sacrococcygeal junction is the fascia propria (endopelvic fascia) of the rectum. This fascia completely surrounds the bowel, is situated just beneath the peritoneum and sends an extension around the prostate or vagina to the symphysis pubis. Just above the sacrococcygeal junction are the triangular ligaments containing the middle

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hemorrhoidal vessels. These ligaments fix the rectum to the lateral pelvic wall. For complete rectal prolapse to occur these must undergo some weakening or destruction and some force capable of dislodging the organ from its position must be exerted.

*Predisposing factors*³ in complete rectal prolapse are congenital anomalies such as a long sigmoid, a low cul de sac, a decrease in the concavity of the sacrum, and a weakness and relaxation (congenital and acquired) of the levator ani and the rectococcygeal and pubococcygeal divisions of the levator ani muscles. Other conditions such as the neurological disturbance of tabes, long standing diarrhea or constipation, and occasionally trauma or perineal lacerations play a part. Prolapse as seen in adults is probably due mainly to a weakening of the levator muscles and relaxation of the fasci propria. The attachments are weakest in the anterior portions because of separation by the prostate bladder or vagina.

CLASSIFICATION OF RECTAL PROLAPSE

Graham emphasizes the point that prolapse occurs at the expense of the anterior rather than the posterior rectal wall. According to Buie⁴ rectal prolapse may be classified under two separate headings, namely *visible* and *concealed*. Under the *visible* rectal prolapse he classifies it as *partial* or *complete*. In the partial type of rectal prolapse the mucosa of the lower rectal wall alone or in combination with the skin which lines the canal is displaced through the orifice and appears externally. In the complete type of rectal prolapse he classifies it further in first degree and second degree. In the first degree the distinguishing factor is that the anal wall is completely everted including all its coats. In the second degree the anal wall remains undisturbed and in normal relationship to adjacent structures except that the wall of the lower part of the rectum including all its coats is invaginated through the anal canal. In a concealed rectal prolapse the hernia is within the anal canal and the upper segments of the rectum including all the coats are invaginated through the lower rectal lumen but do not appear externally. In the cases presented here all the patients had prolapse of the entire rectal wall for a distance of 4 to 6 inches (Fig. 518) and one of them had small bowel within the hernial sac of a massive prolapse. In the other two cases the rectovesical pouch

reached beyond the tip of the coccyx. The rectosigmoid was unduly mobile in all cases.



Fig. 518—Complete rectal prolapse

SURGICAL TREATMENT

Down through the years various types of operation have been devised for operative cure of this condition: the main ones being the types which cause narrowing of the anus and rectum; those that bring about restoration of the pelvic floor; those which cause suspension or fixation of the prolapsed bowel; those in which the prolapsed bowel is resected; and others designed to obliterate the pelvic cul de sac.

Operations designed to narrow the anus and rectum^{5, 6}; suspend^{7, 8, 9} or fix the prolapsed bowel^{10, 11, 12}; and resect the prolapsed bowel^{13, 14} have been tried by one of us on several cases.

with quite unsatisfactory results. For this reason in 1939 an operation was devised and put into practice which so far has given satisfactory results and it is the purpose of this paper to report three cases treated by this method. In reviewing the recent literature it is noted that Pemberton and Stalker¹ in May 1939 reported a similar operation with curative results.

In the exteriorization of benign or malignant growths in the rectosigmoid area the practice has been to divide the pelvic peritoneum at its point of reflection and to free the rectum from the hollow of the sacrum down to the tip of the coccyx. Posteriorly the lower part of the sigmoid and the rectum are only loosely attached to the hollow of the sacrum and after the bowel is freed to the tip of the coccyx it can be lifted up and completely exteriorized. It was our opinion that if the pelvic colon could be pulled up until the rectum was taut and held in this position at least temporarily the cavity between the bowel and sacrum would fill in with scar tissue would produce firm fixation and would also allow the levator group of muscles to regain their tone thereby correcting the rectal prolapse.

Technic of the Authors Operation

The patient is hospitalized for a period of three or four days for preoperative preparation during which time the bowel is emptied by administration of saline purgatives and colonic irrigations. The patient also is placed on a low residue diet. The operation is usually performed under spinal anesthesia. The abdomen is opened through a low left rectus incision extending from the symphysis pubis to the level of or just above the umbilicus. The patient is then placed in high Trendelenburg position a self returning retractor is inserted and the small bowel and the upper abdomen are separated from the pelvis by moist gauze packs. The sigmoid which is usually rather long and mobile is gently pulled up until taut and an incision is made in the peritoneum on both sides of the mesentery of the bowel and carried forward toward the bladder (Fig 519 A). The peritoneum is freed laterally to identify the ureter on each side and is mobilized enough to make a new pelvic floor. The bowel is then lifted up and with the hand behind it in the hollow of the sacrum the rectum is freed by blunt dissection being careful not to injure the hemorrhoidal and sigmoidal vessels. The dis-

secting fingers are carried downward and forward to the tip of the coccyx this will allow the prolapsed portion of the rectum to be pulled up from the hollow of the sacrum. With

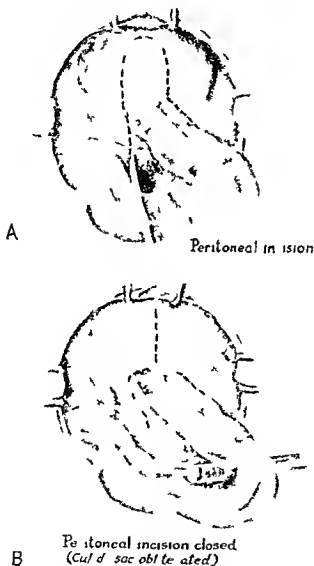


Fig. 519—Operative repair of complete rectal prolapse

the rectum held taut the reflected flaps of the peritoneum are sutured together around the bowel making a level floor and serving the same purpose as the high ligature of a hernial sac (Fig. 519 B). The raw surface of the bowel is then re-peritoneal

ized and a temporary colostomy is performed bringing the bowel up through the lower part of the incision (Fig 570). The wound is closed in tiers leaving a glass rod through the mesentery underneath the bowel. After a period of seventy two hours a T shaped incision is made in the bowel with the electric cautery to relieve distention. The diet is gradually increased.

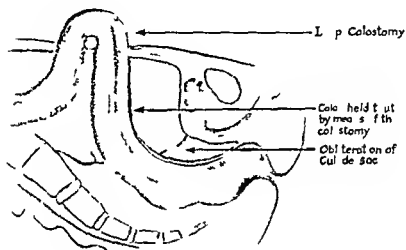


Fig 520—Operation repair of complete rectal prolapse (continued)

and the patient is able to be up and around in a period of two weeks. The patient is then allowed to go home and instructed to return in six to twelve weeks for closure of the temporary colostomy. An extraperitoneal closure is done leaving the bowel attached to the peritoneum and muscle.

CASE REPORTS

CASE I—J W B, a white man aged forty four years, was admitted on November 17, 1939. His chief complaint was inability to control bowel movements. The patient had undergone a hemorrhoidectomy in 1932 but the symptoms of a large mass in the rectum still persisted after operation and he had another hemorrhoidectomy in 1937. Following this he complained of incontinence and that his whole rectum would come out. His history otherwise was negative. Examination revealed a well developed and nourished male

with a rectum which showed no sphincter tone and with 6 to 8 inches of bowel protruding from the anus. The mucosa was inflamed. No ulcerations or evidence of hernia were present. At operation on November 30, 1939, the sigmoid and rectum were found to be redundant and the rectovesical pouch reached down to the tip of the coccyx. The colostomy was closed December 3, 1939. Last examination was made in May, 1940. At this time the patient had complete relief of symptoms. There was no evidence present of prolapse but the rectal sphincter was still somewhat relaxed.

CASE II—B. L. N., a white man aged twenty-four years, was admitted on November 7, 1939. His chief complaint was gonorrhea and trouble with his bowels. He had had a hemorrhoidectomy in June, 1939. He complained of constipation and that on attempted bowel movement a large mass of bowel fell out. Examination showed a well-nourished and developed male with a blood pressure of 120 systolic and 80 diastolic and a urethral discharge. The protruding mass from the rectum measured 3 to 4 inches in length. Its mucosa was inflamed and indurated. No hernia was present. At operation on January 9, 1940, after treatment for gonorrhea, the sigmoid and rectum were found redundant and the rectovesical pouch was deep, extending to the tip of the coccyx. The colostomy was closed February 16, 1940. At the last follow-up in July, 1942, no evidence of prolapse was present and the patient offered no complaint.

CASE III—C. L. S., a white man aged forty-four years, was admitted on April 3, 1939. His chief complaint was pain in the lower part of the stomach and pain in the rectum as if something were pressing on a sore spot. On attempted bowel movement there was a protrusion of the rectum about the size of his fist, followed by pain in the perineal region. These complaints began about October, 1938, had been gradually growing worse and discomfort was constant. Examination revealed a well-nourished and developed male with a blood pressure of 120 systolic and 80 diastolic. There was present a complete prolapse of 3 to 4 inches of bowel and evidence of herniation. At operation on April 17, 1939, a protrusion of the rectovesical pouch extended beyond the external sphincter with herniation of small bowel. A left inguinal hernia was present. Closure of the temporary colostomy was made on June 6, 1939. Follow-up in June, 1941, revealed no evidence of prolapse. The patient had gained 20 pounds in weight following discharge and offered no complaint except postoperative ventral hernia.

COMMENT

A great many operations have been devised for complete rectal prolapse most of which are unsatisfactory at least in our hands. We are of the opinion that the technique of repair of the pelvic floor together with the fixation of the rectum and sigmoid by means of a temporary colostomy as outlined is a logical and anatomical method of attack in these difficult cases and we feel that it is the method that will meet with the greatest universal success. We realize our group of patients is not large but we have had the opportunity to follow them over a long period of time. However the success or failure of an operation cannot properly be evaluated until a large group of patients has been studied. In view of the good postoperative results with complete relief of symptoms the patients returning to normal life we are encouraged to present the cases and the operation for consideration by other surgeons.

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SYMPOSIA

1941

<i>February</i> (Chicago)	MINOR SURGERY
<i>April</i> (New York)	TRAUMATIC SURGERY
<i>June</i> (Lahey Clinic)	DISEASES OF GASTRO INTESTINAL TRACT
<i>August</i> (Mayo Clinic)	SURGICAL TREATMENT OF CANCER
<i>October</i> (Cleveland Clinic)	HYPERTHYROIDISM
<i>December</i> (Nationwide)	MILITARY SURGERY

1942

<i>February</i> (Chicago)	SURGICAL TECHNIC
<i>April</i> (New York)	SURGICAL INFECTIONS
<i>June</i> (Lahey Clinic)	OPERATIVE TECHNIC
<i>August</i> (Nationwide)	INDUSTRIAL SURGERY
<i>October</i> (Baltimore)	EMERGENCY TREATMENT
<i>December</i> (Philadelphia)	NEW TRENDS IN SURGERY

1943

<i>February</i> (Chicago)	GYNECOLOGY AND OBSTETRICS
<i>April</i> (New York)	TRAUMATIC SURGERY
<i>June</i> (Lahey Clinic)	SURGERY OF THE BILIARY TRACT
	SURGICAL DIAGNOSIS
<i>August</i> (Mayo Clinic)	ORTHOPEDIC SURGERY
<i>October</i> (Nationwide)	SURGICAL TECHNIC
<i>December</i> (Philadelphia)	WAR SURGERY

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